S. HRG. 112–375

NASA'S HUMAN SPACE EXPLORATION: DIRECTION, STRATEGY, AND PROGRESS

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE AND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED TWELFTH CONGRESS

FIRST SESSION

NOVEMBER 17, 2011

Printed for the use of the Committee on Commerce, Science, and Transportation

U.S. GOVERNMENT PRINTING OFFICE

74–010 PDF WASHINGTON : 2012

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED TWELFTH CONGRESS

FIRST SESSION

JOHN D. ROCKEFELLER IV, West Virginia, *Chairman*

DANIEL K. INOUYE, Hawaii	KAY BAILEY HUTCHISON, Texas, *Ranking*
JOHN F. KERRY, Massachusetts	OLYMPIA J. SNOWE, Maine
BARBARA BOXER, California	JIM DEMINT, South Carolina
BILL NELSON, Florida	JOHN THUNE, South Dakota
MARIA CANTWELL, Washington	ROGER F. WICKER, Mississippi
FRANK R. LAUTENBERG, New Jersey	JOHNNY ISAKSON, Georgia
MARK PRYOR, Arkansas	ROY BLUNT, Missouri
CLAIRE MCCASKILL, Missouri	JOHN BOOZMAN, Arkansas
AMY KLOBUCHAR, Minnesota	PATRICK J. TOOMEY, Pennsylvania
TOM UDALL, New Mexico	MARCO RUBIO, Florida
MARK WARNER, Virginia	KELLY AYOTTE, New Hampshire
MARK BEGICH, Alaska	DEAN HELLER, Nevada

ELLEN L. DONESKI, *Staff Director*
JAMES REID, *Deputy Staff Director*
BRUCE H. ANDREWS, *General Counsel*
TODD BERTOSON, *Republican Staff Director*
JARROD THOMPSON, *Republican Deputy Staff Director*
REBECCA SEIDEL, *Republican General Counsel and Chief Investigator*

SUBCOMMITTEE ON SCIENCE AND SPACE

BILL NELSON, Florida, *Chairman*	JOHN BOOZMAN, Arkansas, *Ranking*
DANIEL K. INOUYE, Hawaii	ROGER F. WICKER, Mississippi
JOHN F. KERRY, Massachusetts	MARCO RUBIO, Florida
MARIA CANTWELL, Washington	KELLY AYOTTE, New Hampshire
MARK PRYOR, Arkansas	DEAN HELLER, Nevada
MARK WARNER, Virginia	

CONTENTS

WITNESSES

APPENDIX

NASA'S HUMAN SPACE EXPLORATION: DIRECTION, STRATEGY, AND PROGRESS

THURSDAY, NOVEMBER 17, 2011

U.S. SENATE,
SUBCOMMITTEE ON SCIENCE AND SPACE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Subcommittee met, pursuant to notice, at 10:07 a.m. in room SR–253, Russell Senate Office Building, Hon. Bill Nelson, Chairman of the Subcommittee, presiding.

OPENING STATEMENT OF HON. BILL NELSON, U.S. SENATOR FROM FLORIDA

Senator NELSON. Good morning.

Well, NASA is cranking now. Think back a year ago. In the year since the NASA bill—the NASA bill was about the only thing that passed, other than appropriations bills, continuing resolutions that had to be done. Up until the time that we passed the trade bills and the patent reform bill, major legislation, the NASA bill, was the only thing. And now, thanks to this lady right over here, and another lady named Barbara Mikulski, we now have NASA funded, compared to other agencies, very well, given the financial and fiscal environment we are in, in which there are cuts across the board in all agencies.

You compare NASA's budgetary level with the others, NASA has come out very well. And so, we now have to pass the appropriations bill that Senator Mikulski and Senator Hutchison have crafted, as they have worked it out with Congressman Wolf and Congressman Fattah in the final conference report on that minibus appropriations bill that includes NASA.

And what it does is, it funds two lines of rockets in parallel. That is a balanced approach. The one line is developing the commercial rockets to take crew and cargo to and from the International Space Station. And lest you question anything that's going on on the International Space Station, realize that there is a drug that is in its final FDA trials that is a vaccine for salmonella, and there is another drug that is in its, starting FDA trials that is a vaccine for MRSA. And those were developed utilizing the properties of Zero-G.

In addition, and in balance is the parallel line of rockets, and that is the big rocket. And that will have what they now are naming—it's my understanding, Mr. Administrator—Orion. It will have a crew of seven, and it will be the big rocket that will enable us—and it will evolve over time in its capability—to get the components

up into earth orbit, and to go further, then, out in the cosmos, whether that is first the President's target of 2025 for the asteroid before we go on to Mars, whether it's that, and go back to the moon. Those are things still to be determined.

In the meantime, also in parallel, is this plethora of other unmanned space missions. And about to be launched is a Volkswagen-sized Mars rover that has a scooper that can analyze the Martian soil, that has a red beam that will pulverize rocks, and that has two eyes that stick up that will beam back real-time images—with the transmission delay—from Mars back to Earth for earthlings to see this rover going around the surface.

And of course, we took off several months ago to Venus. In the meantime we've done, also, a mission to the Moon—to study the Moon's gravitational field, as well as an Earth-observing satellite that's in polar orbit. So, we've got a lot that's going on. And as we get ready for these two new rockets, there's the modifications to the ground operations and ground equipment.

So, with that as a background, we have a very robust future.

And our first witness is the Administrator of NASA. And then, on the second panel we have the Center Directors from the three primary centers charged with executing NASA's human space exploration initiatives. Bob Cabana is Kennedy Space Center, and of course, he oversees the efforts to transform the center into the next generation launch complex, and where the workforce resides that will 1 day launch the astronauts to Mars. And Mike Coats, Johnson Space Center, the home of Mission Control, the center leading the development of the Orion crew vehicle. And Robert Lightfoot, Marshall Space Flight Center, which has designed every U.S. rocket that has ever launched humans into space, and it's currently designing the Space Launch System.

So, we look forward to this.

I would turn to my colleague, Senator Boozman.

STATEMENT OF HON. JOHN BOOZMAN,
U.S. SENATOR FROM ARKANSAS

Senator BOOZMAN. Thank you very much, Mr. Chairman. I'm certainly delighted to join you, our Subcommittee Chairman, this morning on this very important hearing.

As always, it's a privilege to share the dais with our distinguished Ranking Member of the full Commerce Committee, Senator Hutchison. Without her consistent leadership, along with Senator Nelson, we would not be in a position to hear what I hope will be a very positive message from Administrator Bolden and our other distinguished witnesses from the three key NASA centers.

As many have said, the Nation is at a crucial crossroads in our Human Spaceflight Program. We are, for the first time in over 30 years, without the means of transporting our astronauts into outer space.

Fortunately, the passage of the 2010 NASA Authorization Act last year in an overwhelming bipartisan and bicameral show of support provided the direction needed to remedy this situation as soon as possible.

This hearing is intended to provide the Committee with a progress report on how NASA is doing in carrying forward the pro-

visions of that law, and moving us along the course outlined by the law.

We're in a difficult economic time, as we all know. The fiscal challenges are great. And that is no less true of NASA than the rest of our Federal household.

In the relatively short time I've served on this subcommittee, along with my more casual observations of NASA space flight programs over the years, I've developed a sense of confidence and trust in the hardworking, dedicated people of NASA and their support contractors. I believe the technical experience, expertise and commitment is there to meet these enormous challenges—although, sadly, somewhat diminished over the past year, as we have seen the awkward, unfortunately ill-timed transition away from the Space Shuttle Program to an all too slowly defined set of replacement programs.

We now must move with maximum speed and efficiency within the constraints we face to get back on track.

I look forward to hearing today that we are making real progress in that regard. But I also want to hear if there are any obstacles which will remain in which my colleagues and I can address and remove in the months and weeks ahead.

The effective restoration of U.S. space restoration leadership is simply too important to the well-being of the nation, both economically and competitively, for us to do anything less than our very best to ensure the success of what is now, I hope, our common shared plan for the future of U.S. space flight.

Thank you, again, for convening the hearing, Mr. Chairman. And I look forward to the testimony and exchange of questions and answers to follow. And I yield back.

Senator NELSON. Senator Hutchison.

STATEMENT OF HON. KAY BAILEY HUTCHISON,
U.S. SENATOR FROM TEXAS

Senator HUTCHISON. Well, thank you, Mr. Chairman.

And I want to say first that I'm going to talk about some of the preamble to today's hearing. But, this subcommittee has been instrumental in setting the direction and the course for NASA.

We have provided the leadership. And I, obviously, Senator Nelson, you've been there from the beginning. You have been the spirit, the leader, the little dog that got the bone that never would give it up. All of those things that were necessary to make us go forward as we were watching the Space Shuttle Program come to an end. And I can't say enough good about the never-give-up attitude that you've had.

I want to say, Senator Boozman, you have jumped in in your very first term, and you've met with the staff; you've learned all the issues. You've always been a supporter of NASA, but you're an effective leader. And thank you for taking this subcommittee, caring about it, and being a major force for the things we've been able to do. Thank you.

And I want to say that Senator Rockefeller also has been at our backs. I mean, going forward, he was a little skeptical, frankly, about the direction that NASA was going, and whether it was

worth doing anything. But he became convinced, and he has been a champion, along with us, to get our program back on track.

So, I just want to say that it has taken all of that, along with great leadership from the House, to get where we are.

And I thought the Congressional Gold Medal Ceremony yesterday was inspiring. It was beautiful. And I thought it should inspire all of us that all the work that we've been doing for the last 2 years to get us on track is not only well worth it, but essential; that we can't be the country that is backing off at a time when other countries are gearing up to go forward.

And I think we have some reestablishment to do to preserve our leadership in human space flight. And we are here to help make sure that happens.

As we were winding down the Space Shuttle Program, we were not in sync with the administration. And I think Congress was exercising its prerogatives and trying to come to terms with the fact that we weren't going in the right direction with the right amount of speed and vigor.

But, I will say that things have changed, I believe, and finally, in a meeting that we had about 2 months ago with the Director of the OMB and others, and Mr. Bolden and his Deputy, we've, begun, I believe, to forge a consensus that now has resulted in the September 14 announcement that the Space Launch System design was, in fact, a reality. And the agreements, then, became formalized, public, and contracts, I think, I'm hoping you're going tell me, are let, and we're on a roll here.

And I will also say, while talking about the impetus that we have—Barbara Mikulski has been a champion. I changed subcommittees on Appropriations in order to be ranking on the Subcommittee that would assure that the authorization bill that we passed would be fully implemented. I couldn't have done it without a partner like Barbara Mikulski. And I believe her interest in, and approach to, the science mission of NASA was an enhancement to assure that we would be doing the space program in a way that would complement and augment the science part. And so, we're a team on that score.

So, now I just want to renew my pledge for the next year and month and a half, that we will continue to go forward vigorously. We will conduct oversight vigorously. But, I'm hoping that we won't need the nudging, or the questioning, because we'll all have that team effort feeling, that we're going forward with the same goals, with the same vigor, with the same trust that really is necessary to accomplish what we all want, I think—and that is, for us to take our astronauts to the space station and beyond on our own momentum, with our own great employees, with our own experienced staff. And that's my goal for the next year and month and a half for this agency, and being on the appropriations side, as well as the authorization side. We can make this happen.

So, thank you, Mr. Chairman. And I'll look forward to hopefully hearing a progress report from the Administrator that is a positive one, and we'll all go forward singing Kumbaya. Thank you.

[The prepared statement of Senator Hutchison follows:]

PREPARED STATEMENT OF HON. KAY BAILEY HUTCHISON, U.S. SENATOR FROM TEXAS

Thank you, Chairman Nelson, and Ranking Member Boozman for holding this very important hearing today.

I am delighted to join you in hearing what I hope will be 11Good News11 from NASA regarding the steps that have been taken and will be taken, to implement the 2010 NASA Authorization Act, especially with regard to development of the Space Launch System, the Multi-Purpose Crew Vehicle, and the plan for effective utilization of the International Space Station.

It is fitting that this hearing is taking place the day after four of our countries' most celebrated astronauts were awarded the Congressional Gold Medal.

Today's hearing is about the progress NASA is making in re-establishment and preservation of America's leadership in Human Space Flight and Exploration.

This is very critical point in the history of the American Space Program. The United States is, at this moment, only barely a "spacefaring nation," in that we have no independent means of transporting astronauts into space.

The fact that we have the International Space Station and are able to live and work there is the primary toe-hold we have on the claim to true "spacefaring status" as a nation.

That is simply unacceptable. None of us like it; we all want to fix it, and this hearing will, I hope, give us a measure of confidence that we are on the path toward the solution. As my colleagues and Administrator Bolden know, it took us a while to get to the point where we were in full agreement with the basic design of the vehicles that will restore our human space flight capability.

But a little over 2 months ago, in a meeting with Jack Lew, Director of the Office of Management and Budget, Senator Nelson and I, and the Administrator and Deputy Administrator of NASA, we finally got there.

We agreed that we would all work together to find the resources and establish the mechanisms to move forward, we saw the formal announcement of the decision.

On September 14, based on our agreement, NASA announced the way forward for the Space Launch System. Allowing America to continue to support a manned space program worthy of our Nation storied history in space.

Following that meeting and agreement that we would all work together to find the resources and establish the mechanisms to move forward, we saw the formal announcement of the decision.

As is always the case, actions speak louder than words.

Today, I am looking to hear about those actions. I believe they will reflect the kind of movement we have been seeking, but I also know they will represent only the beginning.

We have a long way to go, and we must see an aggressive and sustained commitment to this undertaking.

I assure you that I will do my part over the coming year, to ensure that commitment is real and that we are well on our way to ensuring American leadership in human space exploration.

Thank you again, Senator Nelson and Senator Boozman. I look forward to hearing the testimony today and the responses to the questions from the Committee.

Senator NELSON. Thank you, Senator Hutchison. Thank you for your heartfelt remarks.

I have a great colleague from Florida. And on things that affect our state, there is very little daylight between the two of us. And this is another one of those subject areas—space.

Senator Rubio.

STATEMENT OF HON. MARCO RUBIO, U.S. SENATOR FROM FLORIDA

Senator RUBIO. Thank you. Are we in opening statements? Or are we in questions?

Senator NELSON. Yes.

Senator RUBIO. OK. Thank you. I apologize for being a few minutes late, and echo your sentiments, and likewise, enjoy working with you—particularly on this program, and with our colleagues from Arkansas and Texas, as well.

And let me just say—I do have some questions later on, so I'll be brief. But I wanted to share with you an anecdote that I think will make you feel pretty good, and also gives us an insight to the opportunity we have here.

During the August recess, as we finished here in early August, one of the things I did for vacation is, we rented a car here in Washington and we drove home. And as we were driving home, we went down 95 into Florida, we spent a day at the Kennedy Space Center, where we got to visit and watch some of the things they put on there for visitors. And I hadn't been there since I was 8 years old. My parents took me there for my eighth birthday.

Suffice it to say, a lot has changed. But my kids have never been there. And they left there—especially my ll-year-old—very inspired by what America has accomplished in the past in the space program.

I'll never forget—there's a line. It's from President Kennedy. It's his actual voice, where he justifies America's space ambitions, and he uses the example of someone who emerged from a cave—thousands of years ago-and said, why do we go to space? The same reason why people wonder what was on the other side of that mountain. And, of course, a lot of human progress came as a result of that. And America's space program has been a leader in that regard.

And, as we were leaving there, we watched a film about the first lunar landing. And my 11-year-old daughter turned to me and asked me, "Why don't we go to the Moon anymore?" Which is not just a specific question, but in general, I think the question that younger Americans have is, why don't we do great things anymore?

And I think we do great things. I think it's important that we remind them of the things we've accomplished, and all the things that are going on in the unmanned programs as we build toward manned capability once again.

But, I really think the space program is indicative of everything that's phenomenal about America. We're a nation of dreamers. We're a nation of people that are intellectually and scientifically curious. I don't think I need to justify or outline to the members of this committee all of the commercial, scientific, military and economic progress that has come as a result of our space program.

But, if you want a way to inspire young people in America to go into science, math and technology, you know, the space program probably can do that better than any other national endeavor that we have.

Just a few moments ago I had a meeting with the first lady of El Salvador. And as she was departing, she picked up her iPhone, or, her Blackberry, and showed me pictures of her 4-year-old son. And you'll never believe what her son had on the table. He had a rocket that said USA on it, a little model rocket. This is the first son in El Salvador, a 4-year-old. And I asked her, "What does he want to be when he grows up?" She says, "He wants to be an astronaut."

And that is what America's space program has meant to our role in world leadership, is that there's a four-year-old boy in El Salvador, the first son, the son of the president, who wants to be an astronaut, and he's inspired by America's space program.

There's no replacement for our country in the world. There are a lot of great nations that are emerging, but there's nothing out there that can take our place. And nothing is more indicative of that than our space program.

So, obviously, we recognize the challenges we face, but also the extraordinary opportunities.

And I want to thank you and everyone at NASA for the hard work you do. And I hope that during my 6 years here in the Senate—or, I guess, 5 years and 2 months that I now, that I've, you know, run out the clock on 10 months here—that I'll have an opportunity to watch as America's space program remains a leader in the 21st century.

So, thank you.

Senator NELSON. General Bolden. Thank you for being here.

STATEMENT OF HON. CHARLES F. BOLDEN, JR., ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. BOLDEN. Mr. Chairman, thank you for allowing me to be here.

And to you and the other members of the Subcommittee, I want to thank you for the opportunity to appear before this committee today, and to discuss the outlook for NASA's Human Spaceflight Program.

Allow me first, though, to thank the Congress for approving, and then yesterday awarding the Congressional Gold Medal to Astronauts Senator John Glenn, Neil Armstrong, Buzz Aldrin, and Michael Collins.

And, Senator Nelson and Senator Hutchison, I especially thank you both from the bottom of my heart for your inspiring words yesterday during the ceremony. It meant a lot.

Contrary to popular belief, this has been an incredible year for NASA. We have completed assembling and outfitting the U.S. Onorbit Segment of the International Space Station; we've taken key steps in moving into the future of exploration beyond Low-Earth Orbit; and we've watched a private company orbit a spacecraft around earth and successfully deorbit and retrieve it intact; celebrated the 50th Anniversary of human spaceflight; and witnessed the successful, safe conclusion of the historic Space Shuttle Program.

Orbiting about 220 miles above Earth right now, the International Space Station, or ISS, represents an unparalleled capability for human space-based research, with science facilities that can support a variety of disciplines. The Station holds the promise of new discoveries in areas directly related to NASA's exploration efforts, and in field that have terrestrial applications and can improve life here on Earth.

NASA has engaged other organizations in the ISS program, and in August of this year we finalized a cooperative agreement with the Center for the Advancement of Science in Space, or CASIS, to manage the portion of the ISS that operates as a U.S. National Laboratory to increase usage and maximize its potential.

The ISS will provide opportunities to scientists and technologists throughout at least 2020. And with yesterday's successful docking

of Soyuz 28S and the planned December docking of Soyuz 29S, we'll restore the ISS crew complement to six for the nominal 6-month duration.

To support the ISS, NASA implemented the Commercial Orbital Transportation Services, or COTS, effort to develop and demonstrate cargo transportation capabilities, and the Commercial Resupply Services, or CRS, contracts to procure cargo services to and from the Station.

NASA is pleased with the progress being made by both of these efforts and we anticipate that Space Exploration Technologies, Incorporated, or SpaceX, and Orbital Sciences Corporation will begin transporting cargo to the International Space Station under their respective CRS contracts next year, in 2012.

NASA is investing in the development of private sector human spaceflight capabilities through the Commercial Crew Development Initiative. Now the Agency is taking the next step through the Commercial Crew Program—a partnership between NASA and the private sector to incentive companies to build and operate safe, reliable and cost-effective commercial human space transportation systems.

On September 19, NASA released a draft Request for Proposal for Phase 1, and the Agency plans to release the final RFP for this effort by the end of this year.

NASA is aggressively moving forward with our next generation human spaceflight system by developing the Orion Multi-Purpose Crew Vehicle, or MPCV and Space Launch System, or SLS, which will take astronauts beyond Low-Earth Orbit.

NASA's plans include an uncrewed system test flight of the Orion and SLS in 2017, and a crewed flight test in 2021.

In May I approved the Orion-based reference vehicle design for the MPCV, as Orion mapped well to the scope of our deep space MPCV requirements. The Agency's current contractual partnership with Lockheed Martin Corporation will therefore be used for at least the development phase of the Orion.

In early Fiscal Year 2014, NASA plans to conduct Exploration Flight Test–1, or EFT–1—an uncrewed test mission using an early production variant of the Orion—that will help validate the vehicle's heat shield performance. In September I selected the design for the SLS, which will take our astronauts farther into space than ever before.

Early flights will be capable of lifting 70 to 100 metric tons, evolving to a capacity of 130 metric tons.

SLS will use a liquid hydrogen and liquid oxygen propulsion system based on the Shuttle Main Engines, and an upper stage that uses the Ares I J2X engine.

While NASA plans to use five-segment solid rocket boosters, for at most the first two initial capability flights there will be a competition to develop the follow-on boosters.

The Orion MPCV and SLS launcher will provide the United States with flexibility to conduct missions to a variety of compelling destinations beyond LEO, such as the Earth-Moon or Sun-Earth Lagrange points; near-Earth asteroids, the Moon, and the moons of Mars, and, yes, Mars itself.

As we look to the future of human spaceflight, NASA is working with the National Research Council to develop roadmaps to guide our technology investment strategy. We're exploring innovative ways to drive a rapid pace of progress; reduce lifecycle costs; and minimize the risk of incorporating new technologies into system designs.

NASA is also actively engaging with the international community through both the ISS partnership and the International Space Exploration Coordination Group, or ISECG, which recently released the initial version of a Global Exploration Roadmap. The GER examines options for expanding human presence into the solar system, with a human mission to explore the surface of Mars as its ultimate goal.

NASA, with our commercial and international partners, has embarked on a new phase of human space exploration and development. In LEO, we see the culmination of the efforts of many nations to construct the ISS and the beginnings of a new way of doing business. The use of commercially provided services rather government-owned vehicles to transport crew and cargo from earth to LEO and back. This will enable NASA to focus on sending our astronauts on missions of exploration beyond LEO with the Orion and SLS. We're committed to developing an affordable, sustainable next generation human spaceflight system that will enable human exploration, scientific discovery, broad commercial benefits, and inspirational missions that are in the best interest of the Nation.

We need your continued support to provide the funding required for this and all our human spaceflight efforts.

Mr. Chairman, I'd be happy to respond to any questions you or other members of the Subcommittee may have at this time.

[The prepared statement of Mr. Bolden follows:]

PREPARED STATEMENT OF HON. CHARLES F. BOLDEN, JR., ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and members of the Subcommittee, thank you for the opportunity to appear before you today to discuss the outlook for NASA's human space flight program. This has been a remarkable year, as we have completed assembling and outfitting of the U.S. On-orbit Segment (USOS) of the International Space Station (ISS), allowing us to focus on full utilization of the Station's research capabilities; taken key steps in moving forward into the future of exploration beyond Low-Earth Orbit (LEO); celebrated the 50th anniversary of human spaceflight; and witnessed the successful conclusion of the historic Space Shuttle Program. We are also pleased with the progress our industry partners have made in developing an American capability to transport cargo and eventually astronauts to the ISS, and end the outsourcing of this work to foreign governments. More importantly, this will add a critical level of redundancy for transporting cargo and crew to the ISS. A robust transportation architecture is important to ensuring full utilization of this amazing research facility. Enabling commercial crew and cargo transportation systems in LEO allows NASA to focus on developing its own systems for sending astronauts on missions of exploration beyond LEO. This split between commercial and Government systems allows for a cost effective approach to promote a broad base for human exploration by the United States.

International Space Station

The ISS is the culmination of the efforts of the United States and its Canadian, European, Japanese, and Russian partners to work together to construct a highly complex and capable spacecraft with components built in many nations around the globe, launched from four different space centers, and assembled on orbit by astronauts conducting over 160 spacewalks. It represents an unparalleled capability for human space-based research. The STS–135 mission, flown by Space Shuttle Atlantis

in July of this year, marked the conclusion of the successful Space Shuttle Program after 30 years of flight, as well as the completion of major assembly and outfitting activities on the ISS. The Station, including its large solar arrays, spans the area of a U.S. football field and end zones, and weighs over 860,000 pounds, without its variety of visiting vehicles. The complex has more livable room than a conventional five-bedroom house, and has two bathrooms, a fitness center, a 360-degree window, and, most importantly, state-of-the-art scientific research facilities that can support a large variety of research disciplines. Examples include high-energy particle physics, Earth remote sensing and geophysics experiments, protein crystallization experiments, human physiology research (including bone and muscle research), radiation research, plant and cultivation experiments, combustion research, fluid research, materials science experiments, and biological investigations. Since November 2, 2001, when the crew of Expedition 1 docked with the ISS, the Station has been visited by more than 200 people, and has been continuously crewed for over 11 years. With the docking of Soyuz 28S to the ISS on November 16, 2011, the Soyuz crew exchange capability is restored. The planned December 2011 docking of Soyuz 29S will restore the crew complement to six for a nominal six-month duration.

Beyond being a feat of unparalleled engineering and construction, as well as international collaboration, the ISS is a place to learn how to live and work in space over a long period of time. It is a place to conduct research and development (R&D) that cannot be pursued on Earth due to our gravitational field. The three major science laboratories aboard the ISS—the U.S. *Destiny,* European *Columbus,* and Japanese *Kibo* facilities—as well as external test beds, enable astronauts to conduct a wide variety of experiments in the unique, microgravity and ultra-vacuum environment of LEO. It is important to note that the Station supports R&D across an array of disciplines, including biology and biotechnology, Earth science, space science, human research, physical and materials science, and technology development. This means that R&D conducted aboard Station holds the promise of new discoveries not only in areas directly related to NASA's exploration efforts, but in fields that have terrestrial applications, as well. The ISS will provide these opportunities to scientists and technologists through at least 2020.

In the NASA Authorization Act of 2005 (P.L. 109–155), Congress designated the U.S. segment of the ISS as a National Laboratory, and directed NASA to seek to increase the utilization of the ISS by other Federal entities and the private sector. To this end, on February 14, 2011, NASA issued a cooperative agreement notice, and on August 31, 2011, the Agency finalized a cooperative agreement with the Center for the Advancement of Science in Space (CASIS) to manage the portion of the ISS that operates as a U.S. National Laboratory. NASA has made solid strides in its effort to engage other organizations in the ISS program, and the Agency now has Memoranda of Understanding with five Federal agencies and Space Act Agreements with nine companies and universities.

While the ISS offers extraordinary opportunities for advancing science and technology to other U.S. Government agencies, non-profit research foundations, and private firms, it will also continue to meet NASA's mission objective to prepare for the next steps in human space exploration—steps which will take astronauts beyond LEO to destinations such as the asteroids, the Moon, and eventually, Mars. The ISS is NASA's only long-duration flight analog for future human deep space missions. It provides an invaluable laboratory for research with direct application to the exploration requirements that address human risks associated with deep space missions. It is the only space-based multinational research and technology test-bed available to identify and quantify risks to human health and performance, identify and validate potential risk mitigation techniques, and develop countermeasures for future human exploration.

In addition to the direct research benefits to be gained by utilizing the ISS as a National Laboratory, this innovative arrangement also supports NASA's effort to promote the development of a LEO space economy. National Lab partners can use the unique microgravity environment of space and the advanced research facilities aboard Station to enable investigations that may give them the edge in the global competition to develop valuable, high technology products and services. Furthermore, the demand for access to the ISS will support the providers of commercial crew and cargo systems. Both of these aspects of the U.S. segment of ISS as a National Laboratory will help establish and demonstrate the market for research in LEO beyond the requirements of NASA.

U.S. Commercial Cargo and Crew Transportation Services for the ISS

Commercial Orbital Transportation Services (COTS) and Commercial Resupply Services (CRS)

In the area of commercial cargo transportation, NASA has implemented a two-phased approach for developing and procuring services: Commercial Orbital Transportation Services (COTS) to develop and demonstrate commercial cargo transportation capabilities; and Commercial Resupply Services (CRS) to procure cargo resupply services to and from the ISS. NASA is pleased with the progress being made by Space Exploration Technologies, Inc. (SpaceX) and Orbital Sciences Corporation (Orbital) on both of these efforts.

We anticipate that these providers will begin transporting cargo to the ISS in 2012—a challenging endeavor that will mark a significant milestone for both companies. NASA and these providers have spent many years preparing for the full utilization phase of ISS; now is the time when we will begin to see the fruits of this planning and development. NASA is engaged in ISS utilization and with the help and dedication of these providers; the ISS will be more extensively utilized and positioned to demonstrate the benefits of space-based R&D more widely to the world.

Commercial Crew Development (CCDev)

NASA's investments have been aimed at stimulating efforts within the private sector to develop and demonstrate human spaceflight capabilities through the CCDev initiative. Since 2009, NASA has conducted two CCDev rounds, soliciting proposals from U.S. industry to further advance commercial crew space transportation system concepts, and mature the design and development of elements of the system, such as launch vehicles and spacecraft. In the first round of CCDev, NASA awarded five funded Space Act Agreements (SAAs) in February 2010, which concluded in the first quarter of 2011. Awardees and the amounts of the awards were: Blue Origin, $3.7 million; the Boeing Company, $18.0 million; Paragon Space Development Corporation, $1.4 million; Sierra Nevada Corporation, $20.0 million; and United Launch Alliance, $6.7 million. Under these SAAs, companies received funding contingent upon completion of specified development milestones, all of which were successfully accomplished by the CCDev industry partners.

During the second CCDev competition, known as CCDev2, NASA awarded four funded SAAs that are currently being executed with the following industry partners:

- Blue Origin's work involves risk-reduction activities related to its reusable biconic shaped Space Vehicle, which is to be launched first on an Atlas V launch vehicle, and then on Blue Origin's own Reusable Booster System. As of October 31, 2011, Blue Origin had successfully completed five of ten milestones and NASA had provided $11.2 million of the $22 million planned for this effort.
- The Boeing Company is maturing its concept for a capsule-based spacecraft that will be reusable for up to ten missions and be compatible with multiple launch vehicles. As of October 31, 2011, Boeing had successfully completed five of fifteen milestones and NASA had provided $52.5 million of the $112.9 million planned for this effort.
- Sierra Nevada Corporation (SNC) is maturing its Dream Chaser, a reusable, piloted lifting body, derived from NASA's HL–20 concept that will be launched on an Atlas V launch vehicle. As of October 31, 2011, SNC had successfully completed five of thirteen milestones and NASA had provided $30 million of the $105.6 million planned for this effort.
- SpaceX is maturing its flight-proven Falcon 9/Dragon transportation system focusing on developing an integrated, side-mounted Launch Abort System. Their crew transportation system is based on the existing Falcon 9 launch vehicle and Dragon spacecraft. As of October 31, 2011, SpaceX had successfully completed four of ten milestones and NASA had provided $40 million of the $75 million planned for this effort.

In addition to the four funded agreements mentioned above, NASA has also signed SAAs without funding with three companies: Alliant Techsystems, Inc. (ATK); United Launch Alliance (ULA); and Excalibur Almaz, Incorporated (EAI). The ATK agreement is to advance the company's Liberty launch vehicle concept. The ULA agreement is to accelerate the potential use of the Atlas V as part of a commercial crew transportation system. The EAI agreement is to further develop the company's concept for LEO crew transportation. As of October 31, 2011, ATK had successfully completed one of five milestones; ULA successfully completed two of five milestones; and EAI had completed one of five milestones.

Commercial Crew Program (CCP)

The CCP is a partnership between NASA and the private sector to incentivize companies to build and operate safe, reliable, and cost effective commercial human space transportation systems. In the near term, NASA plans to be a partner with U.S. industry, providing technical and financial assistance during the development phase. In the longer term, NASA plans to buy transportation services for U.S. and U.S.-designated astronauts to the ISS. We hope that these activities will stimulate the development of a new industry that will be available to all potential customers—including the U.S. Government—putting U.S. industry in a leadership role for this new market.

On September 19, 2011, NASA released a draft Request for Proposals (RFP) for Phase 1, entitled Commercial Crew Integrated Design Contract (CCIDC), inviting industry to comment on the process. The final CCIDC RFP will incorporate input from industry as appropriate and solicit proposals for a complete end-to-end crew transportation and rescue system design, including spacecraft, launch vehicles, launch services, ground and mission operations, and recovery. NASA plans to release the final RFP for this effort by the end of 2011.

NASA has been told consistently by a broad range of potential providers that private sector partners expect to be able to achieve the capability to provide commercial spaceflight services to the ISS within 3–5 years from initial development start. NASA's FY 2012 budget request of $850 million for CCP would provide that initial start in FY 2012 for the development of commercial crew transportation systems, which NASA believes would enable services to ISS to be possible in the 2016 timeframe. A reduction in funding from the President's request could significantly impact the program's schedule, risk posture, and acquisition strategy. NASA's initial analysis shows that a FY 2012 funding level of $500 million (consistent with the 2010 NASA Authorization Act) implemented with the current contract-based NASA acquisition strategy would delay initial capability to ISS to 2017, assuming additional funding is available in the outyears.

Preparing for the Next Giant Leap—Supporting Beyond-LEO Exploration

NASA is aggressively moving forward with our next generation human spaceflight system by developing the Orion Multi-Purpose Crew Vehicle (MPCV) and Space Launch System (SLS), which will take astronauts beyond LEO for the first time since the Apollo–17 lunar mission of December 1972. NASA's plans include an uncrewed system test flight of the Orion and SLS in 2017, and a crewed test flight in 2021.

In addition, we are planning to conduct Exploration Flight Test-1 (EFT–1), an uncrewed, two-orbit, high apogee, high-energy-entry, low-inclination test mission that is targeted for flight in early FY 2014. This early exploration flight test is critical to providing early data to influence design decisions and serving as a pathfinder to validate innovative new approaches to space systems development that will reduce the cost of exploration missions. The EFT–1 utilizes an early production variant of the Orion spacecraft that will be integrated on a Lockheed Martin-procured, commercially available heavy class launch vehicle. This launch vehicle will require performance capability to launch a mass of approximately 18 metric tons to provide the energy and guidance capability to achieve reentry conditions required to validate Orion's heat shield performance.

The EFT–1 spacecraft will make a water landing and will be recovered using the 21st Century Ground System (21CGS) recovery forces planned for future human exploration missions. The proposed flight test provides an opportunity to significantly inform critical design by operating the integrated spacecraft hardware and software in flight environments that cannot be duplicated by ground testing.

Orion Multi-Purpose Crew Vehicle (MPCV)

In May 2011, I approved the Orion-based reference vehicle design, outlined in NASA's January 2011 report to Congress, as the Agency's MPCV. The Orion, which was already being built to meet the requirements of a deep-space vehicle, maps well to the scope of the MPCV requirements outlined in the NASA Authorization Act of 2010. The Agency's current contractual partnership with Lockheed Martin Corporation will therefore be used for at least the development phase of the MPCV.

The MPCV will transport crew from the Earth's surface to destinations beyond LEO, eventually providing all services necessary to support a crew of up to four for up to 21-day missions. For very long beyond-LEO missions, such as exploration of Near Earth Asteroids (NEAs) or other planetary bodies, additional elements—a space habitation module for example—will be included to provide long-duration deep space habitation capability.

Mounted on top of the SLS for launch and ascent, the MPCV will be capable of performing abort maneuvers should an emergency arise, to safely separate from the launch vehicle and return the crew to the Earth's surface. MPCV will also be capable of performing in-space aborts if conditions require the immediate safe return of the crew. The vehicle will include the necessary propulsive acceleration capability to rendezvous with other mission elements and return the flight crew from the destination to the Earth's surface. In-space operations, such as rendezvous and docking and extravehicular activities, will be performed with the MPCV in conjunction with other mission elements.

The MPCV will be capable of efficient and timely evolution, allowing for an incremental or "block" development and mission capability approach. This will enable early progress to be made on the fabrication of key design aspects, depending on available funding, while utilizing early testing to buy down risks associated with subsequent block configurations. Each test cycle will also provide an opportunity to on-ramp or off-ramp capabilities as the design evolves.

Moving forward, work on the MPCV will focus only on the deep-space design. While the MPCV could be called upon to service the ISS as a contingency effort—a backup requirement established by the NASA Authorization Act of 2010 (P.L. 111–267)—it should be well understood that utilizing the vehicle for routine ISS transportation would be a very inefficient and costly use of the MPCV deep-space capability. NASA is confident in the ability of our commercial and international partners to provide all currently foreseen support for the ISS. Therefore, there is no intention to conduct routine LEO missions with the MPCV.

Space Launch System (SLS)

On September 14, 2011, I selected the design of a new launch vehicle—the SLS—that will take the Agency's astronauts farther into space than ever before, create high-quality jobs here at home, and provide the cornerstone for America's future beyond LEO human space exploration efforts. This new heavy-lift rocket will be America's most powerful since the Saturn V rocket that carried Apollo astronauts to the Moon and will launch humans to places no one has gone before. SLS's early flights will be capable of lifting 70–100 metric tons before evolving to a lift capacity of 130 metric tons.

The new rocket will use a liquid hydrogen and liquid oxygen propulsion system. The vehicle's core stage will utilize existing Space Shuttle Main Engines (SSME RS–25D) for the initial capability (the first four or five missions, depending on manifest requirements). NASA is planning to develop an expendable version of the SSME (RS–25E) which would have lower manufacturing costs but still provide the engine performance needed, particularly specific impulse in a vacuum environment. NASA's use of the SSME inventory will reduce initial design costs and take advantage of an existing human-rated system. NASA plans to modify and use the existing SSME contract with Pratt & Whitney Rocketdyne to acquire engine servicing and testing for the initial launch system.

The upper stage of the SLS will also use a liquid hydrogen and liquid oxygen propulsion system that includes the Ares I upper stage engine, the J2X. NASA intends to modify the existing Ares I Upper Stage contract with Boeing to develop the SLS core stage and upper stage and will also utilize the existing J2X contract with Pratt Whitney Rocketdyne to continue developing the upper stage engine. The Ares I Upper Stage Production Contract is the only means to meet SLS milestone schedules and avoid substantial duplication of cost, and the Ares I Upper Stage has the same functionality as the SLS Core and Upper Stage elements. NASA also plans to modify and use the existing Ares Instrument Unit/Avionics contract.

While NASA plans to use five-segment solid rocket boosters for at most the first two initial capability flights of the SLS, there will be a competition to develop the follow-on boosters based on performance requirements. On October 7, 2011, the Agency released a Request for Information for Advanced Development of the follow-on systems boosters and received over 30 responses from the aerospace industry.

Beyond LEO Exploration with Orion MPCV and SLS

The primary purpose of the Orion MPCV and SLS heavy lift vehicle is to conduct crewed deep space missions of exploration beyond LEO. Together, they represent the foundational building blocks and key enablers for both our national and international human spaceflight exploration enterprise.

The Orion MPCV and SLS launcher will provide the United States with the flexibility to conduct missions to a variety of compelling destinations beyond LEO, including NEAs, the Moon, the moons of Mars, and Mars itself. The "horizon destination" for human space exploration is Mars, as it represents a compelling destination for both robotic and human space exploration missions. A human exploration mis-

sion to Mars will need vital technology, systems and operational development to succeed in this tremendously bold and challenging endeavor. NASA is working to develop new technologies to support human missions beyond LEO through its Space Technology and Advanced Exploration Systems (AES) programs.

Advancing Space Exploration Technologies

NASA recognizes that any future human exploration effort is largely dependent on developing breakthrough technologies that will enable us to safely go farther and faster into space and at a lower cost. By investing in high payoff, disruptive technology that industry does not have today, NASA matures the technologies required for future missions, while proving the capabilities and lowering the cost of government and commercial space activities.

NASA has been working with the National Research Council to develop Technology roadmaps for the Agency. Much like the Science decadal surveys, these roadmaps will help guide our investment strategy to ensure NASA is advancing the technology it needs for future human exploration. In a draft report released to the public late this summer, the National Research Council made a stark observation by noting that, "NASA's technology base is largely depleted, and few new, demonstrated technologies are available to help NASA execute its priorities in exploration and space science."

Internally, NASA has identified several critical technologies to advance human exploration. Within the Space Technology program Congress authorized, NASA is working toward a FY 2016 flight demonstration to test long-term storage and transfer capabilities for cryogenic fluids. Improved capabilities in this area, in combination with the SLS heavy-lift vehicle, will bring deep-space exploration closer to reality. In addition, Boeing and a team of engineers from four NASA Centers are working together to develop two large-scale, lightweight composite cryogenic propellant tanks for validation and qualification testing in FY 2013 that promise to achieve weight and cost savings as compared to traditional aluminum lithium tanks and may be used on future heavy-lift launch vehicles. Other significant investment includes acceleration of the in-space propulsion and space power generation and storage ground-based technology development efforts required to reduce risk for a future planned solar electric propulsion demonstration that will enable efficient deep-space transportation that is required for deep-space exploration.

Other technology work in development includes the following:

- At Goddard Space Flight Center (GSFC) in Maryland, a team is developing a laser-based, deep space communications system that will revolutionize the way we send and receive data, video and other information, using lasers to encode and transmit data at rates 10 to 100 times faster than today's systems which will be needed for future human and robotic space missions.
- At NASA's Jet Propulsion Laboratory (JPL), a team is developing a Deep Space Atomic Clock, which utilizes a key component from the Johns-Hopkins Applied Physics Laboratory, that will dramatically improve navigation and guidance in future deep space missions, and may lead to an improved Global Positioning System (GPS) in support of activities here on Earth.
- At JPL and the Langley Research Center, engineers are working to develop lightweight planetary entry systems that will enable large mass, high elevation and pinpoint landing capabilities required for Mars and other planetary destinations.
- At Johnson Space Center, a team is working to build on the Robonaut 2 demonstration on ISS and further NASA's development of next-generation tele-robotics systems.

Consistent with NASA's technology roadmaps, the Human Exploration and Operations Mission Directorate's (HEOMD) AES Program is pioneering new approaches for rapidly developing prototype systems, demonstrating key capabilities, and validating operational concepts for future human missions beyond Earth orbit. AES activities are uniquely related to crew safety and mission operations in deep space, and are strongly coupled to future vehicle development. Early integration and testing of prototype systems will reduce risk and improve affordability of exploration mission elements. The prototype systems developed in the AES program will be demonstrated in ground-based test beds, field tests, underwater tests, and flight experiments on the ISS. Many AES projects will evolve into larger integrated systems and mission elements that will be tested on ISS before we venture beyond Earth orbit. The AES and the Space Technology Programs will work closely together to incorporate and integrate new technologies and innovations as they are matured to the point of infusion.

The AES Program is also working closely with NASA's Science Mission Directorate to pursue a joint program of robotic precursor activities that will acquire critical data on potential destinations for future human missions such as the Moon, NEAs, and Mars and its moons. This program builds upon the successful collaboration between science and exploration on the Lunar Reconnaissance Orbiter mission. Later this month, the Mars Science Laboratory will be launched. Onboard the rover will be a Radiation Assessment Detector to measure the radiation environment during the transit to and on the surface of Mars. These data will help researchers to understand how the Mars radiation environment may affect the health of future human explorers.

The development, testing, and evolution of an array of technologies for missions beyond LEO, including propulsion, logistics and resupply, life sciences and human systems, communications, and many other areas, enables what we call the Capability Driven Framework, and it's the basic approach to safely extending human presence to multiple destinations throughout the solar system in a robust, sustained and affordable manner.

In addition to developing building blocks for future missions, the AES and Space Technology programs are exploring innovative ways to drive a rapid pace of progress, streamline project management, and use NASA's resources workforce more effectively. By using small, focused projects to rapidly develop and test prototype systems in house, NASA hopes to greatly reduce lifecycle costs, and minimize the risk of incorporating new technologies into system designs.

A Capability Driven Framework Approach to the Human Space Exploration Architecture

NASA, in collaboration with our international, interagency, industry, and academic partners, continues to refine the analysis, planning, and communication that will be instrumental in defining an effective Capabilities Driven Framework as a long-term strategy for guiding NASA investments in capabilities, technologies, robotic precursors, testing and development, terrestrial analogue activities, and the partnerships that will enable them. NASA's ongoing and cross-cutting Human Architecture Team (HAT) continues the integrated planning, development, and analysis of the human spaceflight exploration and operations architecture, taking into consideration technology, science, and supporting infrastructure.

Leveraging the ISS as an important National research platform and test bed for exploration technologies and operational concepts and other potential missions in relatively close proximity to the Earth are actively being considered as part of the incremental capability build-up approach. These include potential satellite servicing and repair missions, assembly of large structures, or extended duration missions outside the radiation protection afforded by the Earth. The High-Earth Orbit and Geosynchronous Orbit regions provide another opportunity to test spacecraft systems at greater distances and in more challenging environments consistent with the NASA Authorization Act of 2010 (P.L. 111–267), which specifies that the architecture have ". . . the capability to conduct regular in-space operations, such as rendezvous, docking, and extra-vehicular activities, in conjunction with . . . other vehicles, in preparation for missions beyond low-Earth orbit or servicing of [future observatory-class scientific spacecraft intended to be deployed in Earth-orbit], or other assets in cis-lunar space."

When looking beyond near-Earth space and LEO, several missions and target destinations are viable. These include Earth's closest solar system neighbors: the Earth-Moon or Sun-Earth Lagrange points and cis-lunar space, NEAs, the Moon, the moons of Mars, and Mars. Each destination provides unique exploration and operational opportunities. Lunar circumnavigation and flights to Earth-Moon or Earth- Sun Lagrange points hold near-term promise as compelling test locations for the SLS, Orion MPCV, and other key emerging systems. Lagrange points are gravitationally stable regions created by the interaction of the gravity fields of any two large masses; an object placed at a Lagrange point will tend to stay in place for a long time. The Earth-Moon L1 and L2 Lagrange points could therefore be excellent "gateways" for a multitude of exciting exploration missions. The NEAs provide the opportunity to send humans beyond the solar orbit of Earth while holding compelling science and planetary defense knowledge-building potential. In addition to possible scientific prospects, missions to NEAs would afford astronauts the experience applicable to deeper-space missions that would eventually contribute to establishing a permanent human presence beyond Earth. There are a few asteroids which could be visited by the SLS and Orion MPCV in the time-frame under consideration. Additional NEA survey data will be required to identify and refine the catalog of potential targets.

On a slightly longer timeline, the moons of Mars—Deimos and Phobos—present opportunities to blend both NEA and surface mission attributes in a hybrid mission that may be less risk- and resource-intensive than a full Mars surface exploration mission, but still be very much on the enabling path for such a mission. Mars, being the farthest and most challenging destination in the capability-driven plan, represents a long-term goal or horizon destination for human exploration and later longer duration surface habitation. Mars has a plethora of scientifically important and resource-rich targets from which to choose. Collectively, the NEAs, lunar, and Mars destinations also respond to the NASA Authorization Act of 2010, which states that Congress finds ". . . the extension of the human presence from low-Earth orbit to other regions of space beyond low-Earth orbit will enable missions to the surface of the Moon and missions to deep space destinations such as near-Earth asteroids and Mars."

NASA shares the belief of its partners that challenging and exciting exploration missions will be international in nature, so we are actively engaging with the international community, facilitating efforts to collaboratively set the stage for human exploration missions of the future through both the ISS partnership and in the International Space Exploration Coordination Group.

International Cooperation: The Global Exploration Roadmap (GER)

In September 2011, the initial version of the Global Exploration Roadmap (GER) was released by the International Space Exploration Coordination Group (ISECG) and its members. The GER is the culmination of work by 12 of the 14 ISECG space agencies over the past year to advance coordinated space exploration.

The GER starts with the ISS as a foundation, and examines options for expanding human presence into the solar system, with a human mission to explore the surface of Mars as the ultimate goal. The GER lays out a framework for continuing international discussions, including Common Goals and Objectives, two potential scenarios for human and robotic exploration over the next 25 years: "Asteroid Next" and "Moon Next"; and, Human Exploration Preparatory Activities. The exploration scenarios and preparatory activities are not binding on the participating agencies, but they may serve to inform agency decisions related to exploration activities.

Through the work of the ISECG and the GER, many of the world's space agencies have begun collaboratively working on long-range exploration mission scenarios. Agencies are looking for near-term opportunities to coordinate and cooperate that represent concrete steps toward enabling the future of human space exploration across the solar system.

Implementing the Future

In implementing NASA's missions, the Agency's Centers ensure that the future outlined here is brought into being. Three of NASA's Centers focused on human spaceflight goals are the Johnson Space Center, in Texas; the Kennedy Space Center, in Florida; and, the Marshall Space Flight Center, in Alabama. Without these Centers' highly skilled and dedicated workforce and state-of-the-art facilities, realizing the full potential of the human exploration of space would be impossible.

The Johnson Space Center (JSC) leads the development of the Orion MPCV, and the Program is working to make this vehicle affordable and able to meet budget and schedule requirements. As part of that effort, NASA is finalizing Orion's flight test strategy so that flight tests can focus on high risk items earlier in the development cycle when it costs less to change them. Orion has also streamlined NASA's insight and oversight model, using engineering for more in-line development work rather than only oversight. JSC has been working closely with other NASA centers on program-to-program integration to ensure safe and successful flight.

JSC continues to focus on operating, utilizing, and maintaining a safe ISS. The Center is working to enhance ISS capabilities for research and technology, allowing us to use Station as a test bed for deep space engineering demonstrations and building upon our international partnership.

The Kennedy Space Center (KSC) is focused on commercial partnerships to support safe, reliable, and cost effective access to LEO and the ISS, looking for creative ways to collaborate. Currently, KSC has approximately 80 partnership agreements signed or in discussion. A successful example is the historic agreement with Space Florida for use of Orbiter Processing Facility–3 (OPF–3) by Boeing to manufacture and test their CST–100 spacecraft.

KSC's Commercial Crew Program is developing a viable commercial space industry, which is will enable the U.S. to retain jobs and technical expertise, and the Center's 21st Century Ground Systems Program is going forward to build a true multi-user launch complex for our Nation. It is evolving from a Government-centric, gov-

ernment-owned and operated complex, to a true multiuse spaceport with Government and commercial operations utilizing key infrastructure for access to space.

The Marshall Space Flight Center (MSFC) is designing and developing the SLS. The plan for SLS starts where we are, with a talented workforce, robust hardware, and unique infrastructure either already in place or well into development, while providing competitive opportunities for advanced technologies that will be evaluated on both performance and return on investment. The SLS Program is a lean organization that has streamlined its interfaces, workflow, and decision-making processes.

MSFC is also responsible for hardware and payload operations for the ISS and such science missions as the Discovery and New Frontiers Programs and the Chandra X-ray Observatory. The Center continues to lead the way in propulsion, science and discovery, in part because of its exceptional team of renowned experts and many unique, specialized laboratories and facilities.

All three Centers are engaged in both the AES and Space Technology programs developing the essential technologies required for deep space exploration.

It is important to note that while JSC, KSC, and MSFC are represented here today, all of NASA's Centers play a role in the Agency's exploration efforts, whether in the form of providing valuable testing and other support facilities, or operating NASA's robotic science missions. The Agency relies on its personnel and infrastructure around the Nation to accomplish America's achievements in space.

Conclusion

NASA, with our commercial and international partners, has embarked on a new phase of human space exploration and development. In LEO, we see the culmination of the efforts of many nations to construct the ISS. From September 2000 to October 2010, 1,149 investigations were conducted aboard the Space Station, including U.S., International Partner, and National Laboratory Pathfinder investigations. This research involved 1,600 scientists and has already resulted in more than 310 scientific publications. The Station has now entered its operations and research phase, and this phase will continue through at least 2020. This research will benefit NASA's exploration goals, but also go beyond this by enabling other governmental and non-governmental entities to conduct wide-ranging experiments that we anticipate will result in a variety of terrestrial benefits.

All of this research will be supported by a new way of doing business: the use of commercially provided services rather than Government-owned vehicles to transport crew and cargo from Earth to LEO and back again. We are also working aggressively to bring the new domestic commercial cargo providers onboard. The Commercial Crew Program has great promise, but also some significant challenges ahead. Human spaceflight is a very difficult endeavor, and our industry partners will have the responsibility for the full end-to-end system. Private enterprise and affordable commercial operations in LEO will enable a truly sustainable step in our expansion into space—a robust, vibrant, commercial enterprise with many providers and a wide range of private and public users will enable U.S. industry to support NASA and other Government and commercial users safely, reliably, and at a lower cost. NASA is proud to help in laying the groundwork for the emerging LEO space economy.

By investing in space technology research, NASA can be a significant part of the solution to our Nation's economic, national security and geopolitical challenges. NASA's Space Technology Program will support NASA's needs and also act as a catalyst for innovation throughout America's aerospace industries, and it will create new, high technology jobs and innovations in manufacturing that will guarantee American leadership in the new technology economy.

The commercial systems will enable NASA to focus its own development efforts on the Orion MPCV and SLS, which will send our astronauts on missions of exploration beyond LEO. These systems will be flexible enough to support many different mission scenarios, and will serve well in the decades to come. One of NASA's greatest challenges will be to reduce the development and operating costs (both fixed and recurring) for human spaceflight missions to sustain a long-term U.S. human spaceflight program. We must plan and implement an exploration enterprise with costs that are credible and affordable for the long term under constrained budget environments. We are committed to developing an affordable, sustainable, and realistic next-generation human spaceflight system that will enable human exploration, scientific discovery, broad commercial benefits, and inspirational missions that are in the best interests of the Nation. We are also committed to the development of the necessary technologies required to explore our universe. We need your continued support to provide the funding required for this effort.

Mr. Chairman, I would be happy to respond to any question you or the other Members of the Subcommittee may have.

Senator NELSON. Thank you, General.

Senator Boozman.

Senator BOOZMAN. Thank you, Mr. Senator, the senator with the bone that won't let go.

[Laughter.]

Senator BOOZMAN. We appreciate your testimony and appreciate you being here.

The Space Launch System and Multi-Purpose Crew Vehicle are anticipated to fly unmanned in 2017, and then manned in 2021. If SLS is planning for a $1.2 billion flat budget, can you explain what exemptions are made with respect to the budget for those projected dates?

Mr. BOLDEN. Senator, I will let Robert Lightfoot, who's behind me, talk to specifics of your question. But in general, we are assuming that we are going to get $1.2 billion as a starting amount for SLS, and that, as an absolute minimum, we'll be allowed to escalate for inflation. Otherwise, it's a decreasing budget. And I do need to make that very clear. So, that's one budget assumption, if that's what you were asking.

Senator BOOZMAN. Really, what I wanted to know was, if you had a $1.8 billion, what's the difference in getting stuff done?

Mr. BOLDEN. Sir, if I had—every time you give me more money, I can get it done much more rapidly, and I can—given the flexibility of using the funds for exploration, the combination of MPCV and SLS, we can build, we can execute a development profile which resembles what everybody else in the world recognizes is realism, which is, funding expenditures that go up and down over time, the area under the curve, if you want to, stays the same, because I'll spend the same amount of money over a given period of time, but I'll be allowed to vary the amount that's spent each year so that we can keep the two programs moving along simultaneously and get to the same end point together, instead of running the risk of having one ready, and having to wait while we try to bring the other one up to catch up to it.

Senator BOOZMAN. In regard to the Orion MPCV, in your testimony you state that no contract changes need to be made through the development phase. Is there a plan to complete the MPCV manufacturing in its operational phase? When is the development phase for the MPCV expected to be complete?

Mr. BOLDEN. I'll take, for the record, when, you know, the date that the development phase is expected to be completed, because it's an evolving program, and I will have to find out for you the definite date that it's complete.

But in terms of what are our plans for the future with the MPCV itself, we are talking about a developmental program, which you gets you to the point that you're satisfied that the configuration you have and everything else is what you want to go operate with for the rest of your time, and that will, that could end up being a competitively based contract. But that's down the road. We may find at that time that, you know, you want to do similarly to what we did this time with Orion and use the same configuration. But, that's yet to be decided.

Senator BOOZMAN. Very good.

In your testimony you talked about the Exploration Flight Test, and that it will validate innovative new approaches to space systems development which are expected to reduce the costs of exploration missions.

Can you elaborate on what you mean by new approaches, and how cost is reduced? What other benefits are there from, for this flight test? What's the expected cost? How will the flight tests affect risk? Some of those kind of things?

Mr. BOLDEN. Every time we fly, we buy down risk. So, any flight test, it, one of its prime objectives is to reduce the risk on subsequent flights and, eventually, in the operational phase. So, that is always first and foremost in my mind, as a tester.

If you look at the thermal protection system on the MPCV, it is a new system. It's one that's been developed for very specific purpose. One of the primary goals that we endeavor to see with EFT–1 is, are we right? You know, are our models correct? If we find out that there is extremely high fidelity between what the flight test shows and what the models show, it reduces the amount of ground tests that you have to do. It increases your reliance on models. It means you don't have to do as many tests downstream as you wanted to do.

We did a shell buckling test, for example, at Marshall, oh, sometime back this past year—not directly related to SLS—but it demonstrated to us that we overbuild things. We took a segment of a solid—I think it was a solid rocket booster, I've got to get this right—external tank, and we put pressure on it until it failed. We went to failure. That showed us that we build things a lot stronger than we may need to do.

You know, those are little tests, but they help in the downstream design of the vehicles that you're going to do. Every pound we can take out of a design, every piece of wire that we don't have to put in it, means decreased cost. And it also adds to the reliability of the system, because you don't have as many components that you have to worry about. And that's, those are some of the things—and, again, I'll, I'm out of my league here. That's why I brought these three experts behind me. And ask them that question, and they'll give you the real answer.

Senator BOOZMAN. Thank you, Mr. Chairman.

Senator NELSON. Yes, sir.

Senator Hutchison.

Senator HUTCHISON. Thank you.

Mr. Bolden, the President's budgets had been submitted before we had the meeting with Jack Lew, the OMB Director. And as you know, the Appropriations Committee and Congress changed the budget request from the President to fund the SLS system at a level in which it could be completed.

My question is, the 2013 budget—is that being revisited now by NASA and OMB and the White House, to come more in line with what Congress has now set out as the appropriate funding level?

Mr. BOLDEN. Senator, I, first of all, let me thank you very much for hosting the meeting. I thought—and you and I have talked about this—I thought that was a banner day for the country, because it represented, it proved, or demonstrated our ability to get together on both ends of Pennsylvania Avenue, both parties, and

come to consensus on priorities for the future of the Nation. And as you remember, we all agreed that the three priorities for us going forward would be SLS/MPCV for exploration; enhancement of the International Space Station supported by a robust commercial crew and cargo program; and then the James Webb Space Telescope as the hallmark for our science programs.

So, as you see it, establishing priorities was really, really, really important. We are adjusting our budget request now so as to support those priorities, but also to find ways to bring about the necessary expenditure of funds for things like technology development, without which we can't realize those three priorities.

So, while SLS/MPCV is critical for exploration, it represents today state-of-the-art. We can't go to Mars with the state-of-the-art. We've got to think out of the box. These three guys behind me have got to have their people do imaginative things.

What we fly in 2021 when we fly SLS and MPCV on a circumlunar mission, or whatever that demonstration flight is, my guess is, it will not resemble, in many ways, the vehicle that's flown—in terms of internal mechanisms and systems, it may be different from what we fly in 2007—2017. That's why I say it's an evolving program. So——

Senator HUTCHISON. Well——

Mr. BOLDEN. Yes.

Senator HUTCHISON.—let me just see if I can make sure I'm understanding what——

Mr. BOLDEN. Yes, ma'am.

Senator HUTCHISON.—you're saying. And that is, are you going to revisit the 2013 submission? And will it accommodate the numbers that you have said we have to have to build the SLS system more adequately than the submission before our meeting with Mr. Lew?

Mr. BOLDEN. Senator, I the numbers that are being developed for the 2013——

Senator HUTCHISON. 2013.

Mr. BOLDEN.—budget will adequately support what we have agreed to as the priorities for NASA and the Nation. So, that's the purpose for giving it to you, so that, as I've told you all the time before——

Senator HUTCHISON. It will be different. It is being revisited. It can't be what you——

Mr. BOLDEN. We have revisited our budget submission, and that is in work right now in the Executive Office of the President. The budget that will come forward from the President in February will reflect the agreements that have been made between the Administration and the Congress as best we can.

Senator HUTCHISON. Well, I'm very hopeful that that is going to cement our trust relationship, because the original proposal from last time at $1.3 billion is not going to do it. So, we've done the adjustments on our end in the 2012 budget, and if we are in fact all going in the same direction, we would expect some accommodation of that new relationship.

Mr. BOLDEN. Senator, let me make sure that I clarify, make sure that you understand my statement, because you've made a statement about a specific amount. And I think you know, I'm not privy

to discuss specific amounts at this time. But, what I want to emphasize to you is that we have developed——

Senator HUTCHISON. Well, I'm only putting what's already been put out.

Mr. BOLDEN. Yes, ma'am. I'm just saying, you know, we have put in place a plan for the development of the Space Launch System, Multi-Purpose Crew Vehicle, commercial crew and cargo, and enhancement of the International Space Station and utilization through 2020, those being among the three top priorities for the Administration and the Congress.

Our intent is to build a budget that supports that and enables us to bring those in on the schedule that we presented to you.

Senator HUTCHISON. Mm-hm.

Mr. BOLDEN. So, that is our intent. And hopefully, that, you know, we're saying the same thing——

Senator HUTCHISON. But there, the intervening meeting, and, meeting of the minds, and an intervening appropriations bill that should have an impact on what you submitted before——

Mr. BOLDEN. Yes, ma'am.

Senator HUTCHISON.—these——

Mr. BOLDEN. I, you know, as you will hear from the Center Directors, if we are, you know, if today or tomorrow, or whenever it is that the House is going to vote, if the minibus passes and it is signed by the President, that is great news for the Nation. It gives us firm budget numbers to which we can work. It increases the morale in our workforce, because they now know that they're not going to have to wait for 4 weeks, or 8 weeks, or whatever it is——

Senator HUTCHISON. Mr. Bolden, I'm in agreement with you on that.

Mr. BOLDEN. Yes, ma'am.

Senator HUTCHISON. But, what I'm asking is, is NASA going to carry forward, and is the OMB and the President's proposal going to carry forward what we are passing right now, and not come in with another drop that forces us to have to rearrange priorities yet again? That's my question.

Mr. BOLDEN. Let me see if I can understand the question. Are you asking about the balance in allocation of funds within the NASA budget? Are we going to stay exactly where we are now? You mean, between—for example, commercial crew and SLS/MPCV. You know, we have a difficult road ahead in SLS/MPCV at the level of funding that we are right now, mutually agreed to by the Congress and the White House. But these are very difficult fiscal times, and we all agree that we had to take very difficult measures.

We think we have put forth a budget that will enable us to produce a program for exploration. We have a plan in place that we hope will be able to develop a commercial crew program, commercial crew and cargo, that will sustain our operation and leadership on the International Space Station. And those things, you know, right now, I think we have put forth a budget that will do that, and is in compliance with the agreements that you and I made, and——

Senator HUTCHISON. Are you talking about what's going through Congress right now as your——

Mr. BOLDEN. No, ma'am. We're, I thought you were asking me about the 2013——

Senator HUTCHISON. That's what, I am.

Mr. BOLDEN.—budget being developed by the Administration.

Senator HUTCHISON. Well, we significantly changed direction after——

Mr. BOLDEN. Senator, we're not——

Senator HUTCHISON.—we came to the meeting of the minds about funding the priorities.

Mr. BOLDEN. Yes.

Senator HUTCHISON. You told us what you had to have, and we provided it for the SLS.

Mr. BOLDEN. Yes, ma'am.

Senator HUTCHISON. The commercial crew vehicle system has never been short-changed by NASA by your administration, but SLS has. So, we have now set those priorities, and we've agreed to them——

Mr. BOLDEN. Yes, ma'am.

Senator HUTCHISON.—with you and Mr. Lew. All I'm trying to find out, and I'm just wanting a straight answer if possible, is, now that we have set these priorities and we in Congress have put together a path forward, you're not going to backtrack——

Mr. BOLDEN. No, ma'am. And I say again, we are going to live up to the agreement that we made to fund, sufficiently fund a system, a Space Launch System and a Multi-Purpose Crew Vehicle that will enable us to launch a test flight in 2017 uncrewed, and a crewed flight in 2021, and get to Mars by 2030. And that's what I think we mutually agreed to. And that's what we're going to do.

I go back to Senator Boozman's question about what I would do if I had more money. I don't have more money. I'm not going to get more money. So, we will do what is necessary in terms of the allocation of funds so that we do not back off from our commitment to a Space Launch System that can keep us on track for those target dates. I hope that's answering the question.

Senator HUTCHISON. I've gone over my time. And I was hoping for that, what I think was a straight answer. And I will know for sure in February, when we do get the President's budget, that now that we've set this course, that we're going to stay on the course that we're on——

Mr. BOLDEN. Yes, ma'am.

Senator HUTCHISON.—from this day forward, having the, NASA——

Mr. BOLDEN. Yes, ma'am.

Senator HUTCHISON.—budget in the minibus——

Mr. BOLDEN. And, Senator——

Senator HUTCHISON.—appropriations bill.

Mr. BOLDEN.—I do want to make sure what, you know, that, we, this is a great news story, where we are right now. And, as I said, again, you know, the agreement on the priorities——

Senator HUTCHISON. It is a great news story.

Mr. BOLDEN. Yes, ma'am.

Senator HUTCHISON. Just tell me we're going to continue——

Mr. BOLDEN. We're going to continue. We're going to continue——

Senator HUTCHISON. Thank you.
Mr. BOLDEN.—the great news story——
Senator HUTCHISON. Thank you——
Mr. BOLDEN.—yes, ma'am.
Senator HUTCHISON.—Mr. Chairman.
Senator NELSON. And, General, that's asked by a lady who is a bulldog in the Appropriations Committee, as well as this committee.

And just to provide a little more subtext to that colloquy between the two of you: the Administration had originally for the Space Launch System requested roughly—and I'm rounding—$1.7 billion for the SLS in Fiscal Year 2012. That ended up being funded at $1.86 billion in the minibus appropriation. The Administration had originally requested $916 million for Orion, and that ended up being funded at $1.2 billion.

Where you are having some heartburn, General Bolden, is that the President's request for commercial crew was at $850 million. That was funded in the Senate Appropriations Bill at $500 million, but in the House Appropriations bill at $312 million. And so, we were fortunate to get that up to $406 million, on commercial crew. And so, that's the area that we're going to have to work on——

Mr. BOLDEN. Yes.
Senator NELSON.—because we all agree that we want to stop paying as quickly as we can to the Russians for the seats to get to and from the International Space Station. And, that will be revisited as we carry on these discussions.

Senator HUTCHISON. Well, that's true. But, Mr. Chairman, what concerns me is, the Fiscal Year 2013 budget, that was previously submitted before we came to these agreements, was $1.3 billion for the SLS. And that——

Senator NELSON. In 2013.
Senator HUTCHISON. In 2013.
Senator NELSON. Right.
Senator HUTCHISON. Which is completely insupportable if we're going to stay on the agreed to path, which is what I was trying to get him to acknowledge, that we weren't going to shortchange the SLS in the 2013 budget, because they're going to have to—if they're going to keep the agreement, they're going to have to adjust those numbers. I know they want more on the commercial side, but not at the expense of the SLS system, which should have been overtaken by the agreements that we made in my office 2 months ago.

Senator NELSON. And I think that will resolve itself. And especially when you consider that the President proposes, and the Congress disposes. And the Congress has spoken with regard to the direction.

I just think that, as a practical matter, next year we all are going to have to realize the fact that if we want to lessen the time that we're going to have to wait for commercial crew going to and from the Space Station, that that number is going to have to be addressed. But, where we are right now, in this Senator's opinion, we are very fortunate what you and Senator Mikulski did to get that number up to $406 million.

Senator HUTCHISON. That's right. But, what I'm trying to do is suggest to the Administrator that we need to have the support

from the President in the next submission, so that we aren't, in the Appropriations Committee, having to redirect funds.

Senator NELSON. Exactly.

Senator HUTCHISON. And I would be for increasing the commercial. But, I want the President to suggest where we get it, and I want to make sure it's not from the SLS.

Senator NELSON. And I hope that this message is getting back to Jack Lew down at OMB. We got a lot of that done in our meeting that you referenced with the head of OMB. And hopefully, those agreements are going to continue. But, we're on a good track.

Senator Rubio.

Senator RUBIO. Thank you.

I wanted to explore the commercial program. Some of the commercial entities, as you know, have expressed concern about the contracting requirements. I saw testimony in the House by the folks over at SpaceX. They were talking a little bit about the difficulties of providing information that's going to have significant costs and schedule impacts.

And there was an opinion piece recently run in one of the Florida papers that actually used the term, NASA saddling the commercial crew program with costly and schedule-stretching delays created by complex and onerous contracting methods, and project oversight practices which themselves add several years to the gap.

So, I think we all understand the need for certification efforts to ensure that the vehicles are safe and are ready to fly, particularly people.

Can you talk to me a little bit about the efforts we're making to balance this competing interest between safety, and deliverables versus the input that we're getting from the commercial space providers as far as the contracting? And I think, as you get ready for the end, the creative design contract, is it going to reflect some of the comments that we're hearing from the industry on all these sorts of things? I mean, just kind of give us an insight into that, because those complaints are getting a little bit more prevalent.

Mr. BOLDEN. Senator, two of my responsibilities are to live within my budget, and foremost, to ensure the safety of my crews, whether they're traveling to and from the International Space Station, flying on a NASA airplane, or traveling to Mars. And that is what I'm dedicated to do.

We understand the input from some of the commercial—prospective commercial partners. As I mentioned, we put a draft RFP on the street, a Request for Proposal, which actually was—it probably was the third iteration of putting things out that we intended to use as requirements for any vehicle on which NASA personnel fly to and from the International Space Station, or to Low-Earth Orbit. So, we have had the commercial partners working with us over the last 2 years on the development of mutually agreed upon human rating standards.

We now have had input from the commercial, prospective commercial partners on the Request for Proposal that came from the draft Request for Proposal. We've posted for public consumption all of the comments that came from the commercial providers, and we continue to work with them to understand why they think they cannot work under the guidance of FAR regulation.

There are certain things that we have to do by law in order to buy, to purchase goods and services from any vendor. And, I have to be able to come to this Congress and present numbers that just, that verify how I have held a contractor accountable for the money that I give them. If I let them build with no accountability, I don't satisfy my fiduciary responsibility as the NASA Administrator. And I also don't have a way to hold their feet to the fire and guarantee that my crews are going to be safe when they go to orbit.

So, I do appreciate the situation, or, the position of the commercial entities. That is not the position of all of our prospective commercial vendors. I've visited with many of them. Most of them will tell you, they have done fixed-price contracts for the government for decades. They know how to do it; they're very comfortable with it. Their question of us is: we need for you to be very specific in the requirements up front so that we know what we're building to. And that's what we're working on right now.

I cannot let a contractor go off and change configuration every month or week, or whatever it is, without oversight and insight into that. And I think that's the debate we're having with some of the commercial entities right now.

Senator RUBIO. OK. And, my second question is much broader, and it really is—one of the great thrills of my public service was to be at the State level, when we dealt with space program issues there, but largely it was about capabilities, you know, providing infrastructure and help in that way.

Really, here at the Federal level, what's exciting about it is, we get to have a voice in the strategic vision of the program, and I want to explore that with you for a moment. Because I don't know if it's this simple. But there's somewhat of a debate over whether the goals of our space program should be capability-driven versus destination-driven. And that's a valid debate. And maybe there's a third way.

And I personally lean, I think that you inspire people when you say, "We're going to do this." And maybe there's a way to marry the two. As I mentioned to you earlier, my daughter asked why we don't fly to the moon anymore. And it's a lot easier to, I think, get kids excited about, we're going to certain places, President Kennedy did, versus, you know, the other methodology that may be out there. And, as I said, maybe there's a third way, or a way to complement both of those.

Just share with me a little bit—I know it's the first time we've got to interact in a committee meeting like this—your vision—maybe there's a way to marry the two—but, how do we get people excited about space?

Mr. BOLDEN. I think people are excited about space. And it's generational, to be quite honest with you.

Let me first of all say, destination versus capability is not binary. It's not either/or. If we don't have a destination, we don't know what capabilities we need. We are a capabilities, we are putting in place a capabilities- driven program because we have decided—the President has told us, and Congress agrees—our destination, our ultimate destination for humans is Mars. I can't say that any more clearly. The ultimate destination for humans who travel with NASA is Mars. And our timeline for that is the 2030s.

So, we have a place to which we're going; we have a time in which we want to get there. If we were to take ourselves back in time when President Kennedy spoke at Rice University, he said, "By the end of this decade, I want humans to be safely, to be taken safely to, and return from, the moon." He didn't say, July 29, or 19, or, you know, August, or anything. He said, "Before the end of the decade, I want them to go to the Moon."

President Obama has said, "OK, guys, in the 2030s I want you to have humans capable of going to Mars with the intention of landing there." So, that's our destination.

We don't have the technological capability to get humans there safely right now—at least, we don't know that we have that capability. And so, that's why we're doing a lot of things right now. We just tested the J2X engine, which is the upper stage engine for SLS. A full duration test on the upper stage engine at the Stennis Space Center.

We have the MLP, the—you've got to had a launch pad on which this things sits. It just went through rollout, and it's out at Launch Complex 39B right now going through some tests. That's necessary. We tested DM–3, which is the five-segment solid rocket motor. That has been through a fully successful test.

So, we're incrementally going along, developing the capabilities that we need. That's what makes it capabilities driven. We're going to give them to you incrementally, but that's—and it has to be within the budget. That's the hard part for all of us, is to live within the constraints of the budget and get where we're going——

Senator RUBIO. And now, describe—because I'm out of time, too. But just say, on the budget part of it, one of the competing interests we have is, you go out there, people argue, well, should we be spending this money on this with all these other needs that we have? I think one of the ways you justify that is, we get people—and I think we need to do a better job here in the Senate and the Congress—of getting people excited about that destination; of creating a national goal that we all talk about with our kids. I mean, I'd like to see it being discussed at, by the time you're my age, with our kids, America is going to land on the surface of Mars and return, and this is why it's in our national interest to do it. And, I think it's incumbent upon us who are in public service to create a level of excitement, and broad public awareness that the United States is working on big, exciting things like a landing on the surface of Mars.

And so, we should talk in the future about how we explore that. Because I really, really think that that can be a catalyst, not just for our space program, but it can be a catalyst for getting kids excited about science and math, and being a part of that endeavor itself.

So, thank you.

Mr. BOLDEN. We made an effort just the other day to help keep people excited when we announced the start of the recruitment process for the Class of 2013 of astronauts. That's a big deal. You know, there are kids who have been told, if they look at the media, that NASA's Human Spaceflight Program is over. I don't recruit astronauts if I'm not intending to fly them.

Senator RUBIO. Yes. But the people that might walk on the surface of Mars are probably in high school, could be right now.

Mr. BOLDEN. That is very true. And I hope that they want to aspire like the son of, the 4-year-old son of the President of El Salvador, you know. That's where we're going. And kids are excited about that. And that, we intend to keep that excitement.

Senator RUBIO. Thank you.

Senator NELSON. Senator Rubio, as part of your question, I think it's worth noting that Senators Hutchison and Mikulski enabled an increase on the exploration research and development from the President's request of $288 million up to $304 million. And this is exactly what you were hitting at—developing the new technologies that we have to develop if we're going to Mars.

And so, my compliments, again, to the Senators. And I might point out that this is a discussion about the human space program. But I hasten to add that the first A in NASA is Aeronautics, and for aeronautics, the President's request was $569 million, and the appropriations level is $569 million.

So, we have that going. And, of course, that's an extremely important program, because that involves all of us right here, day to day, in our aviation activities.

General I'll just wrap up here, just asking you to comment for the record on, a lot of these, flesh out the near-term missions. And you, in a colloquy with Senator Hutchison and Senator Rubio, started talking about the question of, do we go to the asteroid? Do we go back to the moon first? And, in your answer, this is going to involve international partners, because we're not going to do this alone. And how is the collaboration with the international partners? How is it likely to influence the determination on our way to Mars, that we should do this, or that mission?

Mr. BOLDEN. Senator, we cannot do it alone, as you said. And the international collaboration in everything we do is critical. If I—and I'm, I will talk too long. But I—Senator Glenn got my attention the other night when we had the Apollo 11 crew and Senator Glenn over at headquarters, briefing them on where we are today, to just bring them up to speed.

And, he made a very insightful comment to me. He said, "You know, I like everything you're talking about, but you're talking too much about exploration, and you're not talking about the International Space Station. And you need to make sure that everybody understands that you can't explore if we don't utilize effectively the International Space Station."

And I come around to that because we don't have a binary system. We have to have aeronautics, or we can't land on Mars, because it's hypersonic flight. We have to have a way to get to the International Space Station, or we can't do the capabilities and the technology development that's going to go into the ultimate heavy lift launch vehicle and Multi-Purpose Crew Vehicle.

The way we are going to get there, unless I pay the Russians $460 million a year, is through American entities. And so, they all tie together inextricably. And I've got to do a better job of explaining that.

This is not a competition between commercial space and exploration. It's a collaboration. Our international partners will leave us

if we don't get our act together and demonstrate to them that we can be disciplined, and we can develop collaborative programs that will help humans reach to these destinations that everybody wants to go.

You know, we're doing well. We are still the acknowledged leader in the world in exploration. I watched President de Kirchner from Argentina when we were there visiting a couple of weeks ago, when we showed her the results from the Aquarius/SAC-D mission. It's an Argentine mission that, we built the satellite and launched it for them out of Vandenberg about a month ago. It's already bringing data on salinity in the oceans of the world. I mean, she was like a kid in a candy store. She almost climbed up on the table looking at the charts about ocean salinity, saying, what does this mean for my nation? What does this mean for me as a leader? What do I need to do? The President asks those same questions when we bring him things. You all ask us those questions frequently.

We have got to, though, we have to have international cooperation and collaboration, or else we can't get there.

Senator NELSON. Is there a preference in the international community that they're expressing, to go back to the moon, as opposed, first going to the asteroid?

Mr. BOLDEN. The international community mirrors the sentiment in the United States. Everybody says Mars is the ultimate destination.

You've heard this term, flexible path. I don't know whether it's 50 percent or 30 percent or what. Some of the international partners want to go to the moon because they have interest, and they have expertise to get there. And they don't have any interest in an asteroid.

Many of them want to go to an asteroid, and they want to do it right now, because that's where their expertise lies. If their remote, if their remote sensing, if their forte is remote sensing, they want to go to asteroids. If their forte is resource development, they want to go to the moon. So, it depends on, you know, what it is that's in their best interest.

Everybody wants to go to Mars. And everyone is coming together to go to Mars. And we need to make sure that we pay attention to what's going on offshore, because everybody else is moving steadily together. And we don't want to be left behind.

Senator Hutchison, you're absolutely right: It is essential that we keep the pace of the heavy lift launch vehicle and MPCV going. But, my challenge is to work with the Congress and the Administration to make sure that we don't fall behind, because we can't effectively utilize the International Space Station and maintain our leadership there. It's a challenge but we can do it.

Senator NELSON. And, since everybody's hitched up to the goal of going to Mars, one of the things that you're going to have to do is develop a whole bunch of new technologies.

Mr. BOLDEN. Yes.

Senator NELSON. And, of course, I often think that if we can sprint to Mars in 39 days with Dr. Franklin Chang-Diaz's plasma rocket instead of taking 9 to 10 months. That's a game changer right there. And that's a technology that's being developed. So, who

knows by the time we're ready to go to Mars, what the new technologies are going to be?

Mr. BOLDEN. Yes.

Senator NELSON. OK.

Senator HUTCHISON. Could I just——

Senator NELSON. Yes. Please.

Senator HUTCHISON.—add one thing? And that is, we, none of us have talked about the President may be setting a priority that would rearrange some of the other scientific technology budgets to assure that we can do all of the three priorities that we have agreed are on our agreed list.

Mr. BOLDEN. Senator, that's one, when I talk about prioritization, that's exactly what we're doing. The delicate balance, you know, that we play at NASA is that we have constituents who all have very important things. And as I said, this is not an either-or. You know, there are science imperatives that we have to be able to satisfy if we're going to go to Mars. And you may think they're not significant.

We just launched NPP, which was a developmental satellite for us that is now an operational weather satellite. I've got to have that. If I don't know, you know, if I don't have effective weather satellites, I can't launch. It, it's just, I, there's nothing, you know, no capability that we can drop off the table.

Now, we can drop off individual programs and projects, and that's what we're looking at right now. That's the prioritization that we're talking about. How do we accomplish the critical goals and objectives, but do it with less? You know, how do we synergize human spaceflight with robotic spaceflight? How do we synergize a scientific mission with a human spaceflight need that, you know—and those are what we call precursors.

Every time we launch, we're trying to make life better here on earth. And it doesn't make any difference what that satellite is going to do, what it's stated purpose is. Almost every satellite that we launch in one way or another makes life better here on earth. And that's what we, that's the imperative that I ask our folk to always keep in mind. What benefit is this going to bring to earth, no matter what it's doing?

Senator HUTCHISON. Well, I'm suggesting that the President also has options, not within the NASA budget, but arranging the priorities between NASA and some other scientific priorities, and determining which are the most important. That's an option that hasn't, you know, been talked about today that I want to also have on the table. Thank you.

Mr. BOLDEN. Thank you, ma'am.

Senator NELSON. Senator Warner.

STATEMENT OF HON. MARK WARNER,
U.S. SENATOR FROM VIRGINIA

Senator WARNER. Thank you, Mr. Chairman. And I know time is short on the first panel, and I appreciate the courtesy of getting a chance to ask the Administrator, at least, I've got a series of questions I'd like to submit for the record. I'll just ask him one.

And I again want to thank the Administrator for coming to my state, Virginia, the other night and speaking so well at the Northern Virginia Technology Council.

You know, I want to talk a little bit about, you know, some of the opportunities and plans you might have for continued development at Wallops Island we share with Maryland, a facility that has greatly grown and has wonderful, wonderful potential. And I would like your comments on NASA's future at Wallops, and where you think it might be headed.

I also want to at least note that I know this area has probably already been covered, but I will have a number of other questions in terms of my continued support for commercial space activities on the private sector side, and the growth of that opportunity; and, again, the partnership with NASA. And I know those subjects have been covered somewhat, but I want to get my two cents in on those, as well.

But, if you could speak to some of the developments at Wallops.

Mr. BOLDEN. Sir, specifically, with relation to Wallops, the senior director, or, the Facility Director out there, Bill O'Dell, is working diligently with Orbital Sciences and with MARS, an organization that you know. Our challenge there is completing the launch pad for Taurus II for the Orbital Sciences company, so that they can get off their two demonstration flights for us as early as possible next year in the COTS program, the commercial, our demonstration of their ability to get things to orbit. That's a very high priority for us right now, so we continue to do that.

Wallops is, it's a, I always tell people, it's sort of like Stennis—it's a federal city. Wallops has many agencies that are there. It is our primary domestic balloon launch facility—and I'm not talking about a party balloon, either. We're talking about balloons that are blocks long, that we take down to the Antarctic and launch, and they stay in, over the South Pole, or go up to the North Pole and stay for months at a time. So, Wallops plays a vital role in everything that we do in science, as well as in our exploration, and servicing of the International Space Station.

Senator WARNER. Thank you, Mr. Administrator.

Mr. Chairman, since I was late, I will defer all my other questions for the record in respect to you and the other colleagues on the second panel.

Senator NELSON. Thank you, Senator Warner.

General Bolden, thank you very much.

May I invite up the second panel. I introduced this panel previously.

We'll start in the order alphabetically and thank all three of you—Bob Cabana, Mike Coats and Robert Lightfoot.

Director Cabana.

STATEMENT OF ROBERT D. CABANA, DIRECTOR, KENNEDY SPACE CENTER, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. CABANA. Senator Nelson, Ranking Member Boozman, and members of the Committee, thank you for inviting me to be here today.

I'm pleased to provide a status of ongoing work at the Kennedy Space Center. But first I'd like to thank all of you for your hard work toward providing a budget for NASA in 2012.

KSC successfully made it through an extremely challenging transition this past year, as we safely completed the last shuttle mission and continued our preparations to support both NASA's exploration program, as well as commercial operations from the Cape. This would not have been possible without the extremely talented and dedicated workforce at KSC that deserves our very best.

As we transition to the future, we've focused on providing a strong institutional core that is more efficient, cost effective, and capable of supporting multiple programs. Key steps in making this happen include reducing our footprint, and replacing aging infrastructure with greener technologies; partnering with Federal, state and commercial entities; and reorganizing our workforce to better support future operations.

To facilitate collaboration and partnerships, we established the Center's Planning and Development Office to focus on commercial agreements. These agreements take advantage of KSC facilities that are excess following the shuttle, and are not required for our future space launch system. To date, this office has approximately 80 agreements in various stages of discussion and signature. The most notable agreement between Space Florida and KSC allows the use of the orbiter processing facility and the engine shop for commercial operations.

We've also made significant progress in preparing for the Space Launch System and the Orion Multi-Purpose Crew Vehicle. Pad 39B has been cleared of all shuttle infrastructure and is undergoing a modernization that includes a state-of-the-art lightening protection system, digital control systems, a refurbished propellant distribution system, and a fiberoptic data transmission capability.

In the operations in checkout high bay, hardware is already arriving to support assembly of the Orion test vehicle, currently scheduled for launch in 2014.

The Commercial Crew Program was established at KSC this year, and in partnership with JSC and other NASA centers, it's moving forward to contract for a commercial capability to provide our crews with transportation to the International Space Station. This will relieve us of our dependence on our Russian partners, and allow us to focus our energy on exploration beyond our home planet.

Our 21st Century Ground Systems Program is working to build a true multiuser launch complex. Investments in 21st Century focus on development of the ground systems that not only support the Space Launch System and Multi-Purpose Crew Vehicle, but provide a common infrastructure for other government and commercial users.

Finally, the Launch Services Program at KSC continues to provide the bridge to space for NASA's science missions by procuring and managing commercial launch services and providing payload processing for final launch preparations. Next week, we'll be launching the Mars Science Lab from the Cape on November 25th.

The Kennedy Space Center is moving forward. The potential exists for a revitalization of Florida's Space Coast through further de-

velopment of the 21st Century Ground Systems Program, the growth of commercial crew services, and continued accomplishments of the Launch Services Program. We are committed to the success of these programs and the success of NASA's future exploration in space.

I'd like to thank the Committee for this opportunity to share the bright future of the Kennedy Space Center and the Space Coast. We value your continued support and your confidence in our abilities to serve as the launch complex for America's ambitions in space.

Thank you.

Senator NELSON. Thank you.

Director Coats.

STATEMENT OF MICHAEL L. COATS, DIRECTOR, JOHNSON SPACE CENTER, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. COATS. Good morning, Chairman Nelson, Ranking Member Boozman, and members of the Committee.

I'm privileged today to be here and to be representing the Johnson Space Center. JSC continues to play a leadership role in human spaceflight design, development, operations and training, as well as human health and performance, orbital debris analysis, and curation of astromaterials. JSC continues to focus on safely operating, utilizing and maintaining the International Space Station as a National Laboratory asset.

After the successful launch and docking of the Soyuz vehicle, we welcomed the three new crew members onboard the ISS on Tuesday. They will maintain the continuous 11-year uninterrupted human presence onboard. We are enhancing ISS capabilities for both research and technology, and also beginning the use of the Space Station as a test bed for deep space engineering demonstrations, further building upon our partnership of five space agencies and 15 countries.

We are very proud of our leadership role in the development of the Orion Multi-Purpose Crew Vehicle—a spacecraft that will carry astronauts to new destinations beyond Low-Earth Orbit and will continue to build upon the research and expertise of the Human Research Program to create next generation systems to sustain humans in space.

The Orion program is working to make this vehicle affordable and able to meet budget and schedule requirements. As part of that effort, NASA is finalizing Orion's flight test strategy so that flight tests can focus on high risk items earlier in the development cycle, when it costs less to change them.

JSC has been working closely with other NASA centers on program-to-program integration to ensure safe and successful flight. JSC has taken an active role in the Advanced Exploration Systems Program—a portfolio of projects that target near-term demonstration of the most critical technical challenges for human exploration beyond Low-Earth Orbit. These projects are aligned with overall agency exploration policy as defined by the NASA's Technology Roadmaps and existing program needs.

Finally, JSC is pursuing many collaborative efforts with partners to further innovative strategies for problem solving, to accelerate research and development, and deliver products effectively and efficiently to ensure NASA's leadership in human spaceflight into the future.

Thank you again to the Committee for the opportunity to speak with you today, and I welcome any questions you might have.

Senator NELSON. Thank you.

Director Lightfoot.

STATEMENT OF ROBERT M. LIGHTFOOT, DIRECTOR, MARSHALL SPACE FLIGHT CENTER, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. LIGHTFOOT. Good morning. And thank you, Mr. Chairman and members of the Subcommittee. I appreciate the opportunity to speak with you today and talk about Marshall Space Flight Center, and what we do for NASA and the Nation.

Marshall has served this Nation in space exploration and science and technology development for more than 50 years. We support NASA in the areas of propulsion and space transportation, systems for living and working in space, and in the science and technology for helping us understand the earth and the universe.

The Marshall of today is responding to NASA's new funding and programmatic environment by reorganizing and downsizing to become more affordable, adaptable and relevant to the Nation's needs, while retaining the capabilities we think we bring to the Nation as a center.

Nowhere at Marshall are our historic strengths and our response to today's new realities more evident than in the Space Launch System, or SLS. NASA has selected a vehicle architecture that delivers more performance than the Saturn V, at less cost than the annual budget of the space shuttle.

As SLS evolves from a 70-metric-ton initial payload to its ultimate payload of 130 metric tons, we've inserted competitive opportunities for advanced technologies that will deliver affordable performance. The SLS plan meets the Agency Affordability Goals in several key ways: We have streamlined the SLS programs and processes, and we're also using proven hardware left to us by the Shuttle Program and the Constellation Program that are already in place and well on their way through the development process.

Through these and other initiatives, we expect to flatten the funding curve typical of most development programs and live within the means we've been provided.

While SLS is an important part of our work at Marshall, it's only one part of our diverse portfolio. Our engineers and scientists continue to support the International Space Station by running the Payload Operations Center, where all payload operations run through our center at Marshall.

We also support the environmental control and life support systems that are on the Space Station and will be used in the future.

We're also excited about our efforts in supporting the Office of the Chief Technologist, where we do technology initiatives that they have planned. We're also working to enable the commercial

providers as well, as we do, as they move forward. And we have some key roles we play in the Agency science portfolio.

At Marshall, we're excited about the path forward for the Agency, and we look forward to the new opportunities and the challenges that will bring. But we understand the challenges you guys face as well in Congress. And so, to that means, we've already taken steps to become more affordable and more adaptive as we move forward.

I appreciate the chance to speak with you today. Thank you for what you've done to support NASA. And I'll look forward to your questions.

Senator NELSON. Senator Boozman. You need to go first. If you need to leave—Senator Hutchison?

Senator BOOZMAN. Let me go ahead and yield my time now to Senator Hutchison.

Senator NELSON. Sure. All right.

Senator Hutchison.

Senator HUTCHISON. OK. Well, thank you very much. Because I do have another appointment. That would be great.

I want to ask generally, each of you, how you've restructured your workforce organizations to support the exploration efforts, the International Space Station efforts, and the commercial resupply and crew programs. Obviously, we've talked a lot already about going forward with both the commercial trajectory as well as Orion and SLS.

How are you accommodating your workforces and the downsizing that all of you have had to do, and to assure that you are supporting the joint goals that we have talked about, that we all have with those priorities?

Mr. COATS. Well, Senator, I'll be frank. It's been a difficult couple of years for the workforce—amazing workforce—at the Johnson Space Center. We have had two major programs come to an end—the Shuttle Program and the Constellation Program—and we've laid off about 3,500 people, about 20 percent of our workforce at the Johnson Space Center.

But, I've got a team down there—and I know Bob and Robert do, too—really talented and dedicated people. They're awfully proud of their history. I can't be more proud of how they handled the last two shuttle missions, knowing a lot of them were going to be laid off. They finished final assembly of the Space Station, and it was as smooth and seamless as you could have asked for.

But this team wants to look forward. As one young lady told me, "We're awfully proud of our history, but we'd like to go make some history of our own out there." The team wants direction; they want support from the country; they're anxious to get started.

So, we have tried very hard to transition the team off of the Shuttle Program, off the Constellation Program, on to the new things we're working on, including the Space Station, of course. And I think it's going reasonably well. They're excited—frankly, they're excited about the Authorization Act we had last year. The seemingly endless series of continuing resolutions—hopefully, the minibus bill will bring that to an end. They're excited about that. Having direction, having support from Congress and the Administration means an awful lot to the team down there.

They're excited about working on MPCV. When Charlie announced we were going to continue the Orion MPCV back in May, that was a huge deal at the Johnson Space Center. Extending the International Space Station to 2020 and beyond was a big deal down there. They're excited about that, and the things that we're doing on the International Space Station—not only the experiments, 150 experiments or so that we're running at any one time, but the test bed aspect of the Space Station and how important it is for exploration. That is very, very important to the team down there.

We're working on the new technologies, as Senator Nelson talked about how important that is for exploration. So, the team is looking ahead; they're excited; they're proud of their past; but they're anxious to make the next 50 years just as successful as the last 50 years.

Senator HUTCHISON. Thank you.

And, Director Cabana?

Mr. CABANA. Senator, I think the biggest change to KSC is, KSC has always been dependent on large single-government programs in the past, and we really are kind of transitioned to be this multi-user spaceport of the future.

Senator HUTCHISON. Mm-hm.

Mr. CABANA. And we're making that happen. When the shuttle landed, I mean, the team just performed flawlessly right up to that last mission. And it was really hard. In July, after Atlantis landed, the very next day, 2,500 more people walked out the door. The Constellation team, when the program was canceled, there was a huge disappointment. But that team now is transitioned into the 21st Century program, and they are excited about making KSC a true multi- user spaceport that supports not only our Space Launch System, but also commercial operations from the Cape and how that can happen.

We've tried to make a strong engineering team that doesn't support, you know, it was embedded within the Shuttle Program. Now it's going to be an engineering team that can support multiple programs.

So, I think, that's the biggest change. What I've noticed lately is, having a clear path forward, and now the funding to execute that plan, it's been a huge boost to the team. They are ready to move out and make this happen. And that's, I can't say enough good things about them. If you point them in the right direction and give them the tools and resources to get the job done, they're going to make it happen.

So, I think we're turning the corner. I think we're building toward the future, and folks are excited about making it happen.

Senator HUTCHISON. Mr. Lightfoot?

Mr. LIGHTFOOT. I think that for Marshall Space Flight Center, having just the direction and the plan to go forward has been a big key for us, getting past that uncertainty.

But one of the things that—and I agree with everything that Mike and Bob have said about what we're trying to do from an Agency standpoint—but, one of the things that we did early on, I think, as a team—not at our centers, but as a group of center directors—is, we decided that we needed to stay in contact. It's very

easy in a time of uncertainty to circle the wagons and, you know, become Marshall, Johnson and Kennedy. But we decided early on in this that we were going to stick together and make sure we were talking on a pretty routine basis.

And we tried to transfer that on to our teams as well. I have two great colleagues here. I have 10 great colleagues overall. But these two guys have stuck by me, and we've stuck with each other through all this process, and make sure we're talking and communicating as much as we can. And I think that's been critical for our workforce to see that. And it's been one of the biggest things that's got us through this transition.

And now I think it's one of the things that's been the impetus to allow us to be ready to move forward.

Senator HUTCHISON. That's very positive. And I'm glad to hear you say that, because the sharing, obviously, is going to create efficiency. So, that's good news. And I just hope that we will be able to continue to utilize the great workforces that you have, accommodating to the new needs and the new challenges that we're all facing to achieve these goals that we've suggested.

So, thank you very much.

Thank you, Mr. Chairman.

Senator NELSON. That is good news, a good positive direction.

And, Senator, in response to your question to Director Cabana, would you further flesh out the fact that in this budget that Senator Hutchison and Senator Mikulski passed, that for the modernizations, for you to re-do the ground facilities to accommodate these new rockets, plus the 21st century, you're looking at funds available up to $484 million in this fiscal year, in this appropriations budget.

Mr. CABANA. Yes, sir. And I think that's really important. The $316 million that comes from SLS toward 21st Century, that's money that's going to go into Launch Complex 39 that directly supports preparing that launch complex to support the heavy lift rocket. The additional $168 million that has come to 21st Century, we're using that in conjunction with the other money. The modifications that we're making, we have to make them to support SLS.

And I'd like to bring out, if we look back on the Constellation money, while we were under the continuing resolution, we did not, that money was not wasted. All the Constellation money that came to KSC we specifically said, what can we do that's generic to prepare Launch Complex 39 for the future, for commercial and for a heavy lift rocket coming, so that it wasn't specific, but it still made progress toward preparing for the heavy lift rocket? So, I think it's critical that those funds are used properly. And we are making sure that we support SLS.

To go back to the Senator's question and comment on what Robert said about us working together, one of the largest problems with a big program like this is the integration of it. And we have downsized our programs so that they are less intensive as far as the number of personnel is concerned, so that they are less costly. But having the crew vehicle at Johnson, the rocket at Marshall, and the launch complex at KSC, we are working together. I think our teams that, each project program manager at each of those

three centers, work very closely with each other, and with us as we prepare, you know, the O&C High Bay for Orion coming together.

So, I think it's really important, it's critical, that we do work together, and we are utilizing those funds to the most efficient manner that we can.

Senator HUTCHISON. Thank you.

Senator NELSON. Thank you, Senator.

Senator Boozman.

Senator BOOZMAN. Thank you, Mr. Chair.

With your permission, I think Senator Rubio has to go.

Senator NELSON. Sure.

Senator RUBIO. And I apologize. I have an 11:45 engagement.

Good morning. And thank you for being a part of this.

Director Cabana, I wanted to actually just—and I think you've touched upon it in your opening statement and your answer to some of the other questions—just to elaborate some more on what we're doing at Kennedy Space Center to help with the transition from the Shuttle Program, particularly the, you know, how we're identifying uses for some of the facilities that are no longer needed in support of the shuttle operation; how we're helping transition people; some of the good news that we've had recently about people coming in; that sort of thing.

Mr. CABANA. Sure. Approximately a year ago we went out with a notice of availability on facilities at Kennedy Space Center. As a result of that, we had a lot of interest from commercial companies coming to work at KSC.

As we transition from the shuttle, this excess capacity that we have—not only in personnel, which is our key, but in facilities—you know, we have to, I can't maintain them. I'm, with the reduced budgets that we have, I do not have the money for the maintenance and operations of these facilities. We don't have the money to tear them down even. They'd just be sitting idle, falling apart.

But we do have commercial companies that are interested in utilizing them. And I think our partnerships are going to be the key to the future, to make sure that we capitalize on these assets and that they don't go to waste.

So, if we have no definitive use for them to support the Space Launch System, we are looking for commercial companies to come in. And the best partnership that we have has been through the State of Florida and Space Florida. It has worked extremely well to allow them, through a use agreement, to take over OPF–3 and make it available for commercial operations. They in turn are leasing it, this first model, to the Boeing Company for the assembly and processing of the CST–100 capsule.

As OPF–1 and 2 have become available, we have other folks that are interested in bringing work to those facilities also. We're making sure that the work we bring in supports NASA's mission and commercial operations at the Cape—commercial space operations, not just anybody.

So, it's a long process. It's much more difficult than I thought, to get all the agreements in place to make it happen. But, having this first model now, I think it will be easier as we move forward in the future.

Senator NELSON. Senator Boozman.

Senator BOOZMAN. Thank you, Mr. Chairman.

I want to thank all of you all for being here, and thank you for your hard work. You've had a very difficult job the last few years.

I had the opportunity to be down to try and watch one of the launches, and it was scrubbed, but it was still really good being there.

I know the most difficult times in my life have been where you don't know where you're at. And this has been very difficult for yourselves, your employees that have worked so hard, and really made a program that has identified the United States throughout the whole world. So, we can be very proud of that. Hopefully, we're starting to have some reassurance, some continuity to the program, so that that will settle down. But, again, we appreciate all that you're doing, and have done through a very difficult time.

I've just got a couple things. And then I have a couple things that I'll submit for the record.

Senator BOOZMAN. Mr. Coats, in Mr. Bolden's testimony, he discusses an exploration flight test that I asked about. Can you describe in a little bit more detail, about the test, its primary goals, the benefits that we'll get from that, and how beneficial to the JSC?

Mr. COATS. Senator, one of the things we've learned, that I've learned in 33 years in this space business in one role or another—and Bob and I certainly learned it as test pilots—the earlier you can test things and discover problems, the more money you're going to save down the line. So, having an early flight test has always been one of the options, and one of the important priorities for us.

I think several things came together to make what we call, we're calling now the Exploration Test Flight-1 much more feasible. I think, getting some agreement between Congress and the President and the Administration on the direction of the space program; having some certainty in the budget and so forth has made EFT–1 much more viable. We've still got a long ways to go. We've got the find about $163 million in the MPCV budget to pay for that. But, if we can fly the EFT–1 flight in 2014, I think we'll mitigate the risk down the line, and the costs of the program, tremendously.

Of course, the difference you need to understand between Low-Earth Orbit, being in orbit in Low-Earth Orbit and coming back from deep space is, we've got much higher speed entry. So, it's not quite the same as coming back. So, if we can do an EFT–1—we're not going to go into deep space, but we're going to go way out there and come back in, a high speed entry, which will test a lot of the things that we can't test with a normal LEO reentry out there.

We need a heavy lift rocket, a Delta IV rocket, and we got a pretty reasonable deal, I think, from a contractor on that rocket. So if we can use that to lift the vehicle way out into space and bring it back, we can test the reentry capabilities.

There are 16 items that we have on our high-risk list, if you will. We'll test 10 of those on EFT–1. And I think that's very, very important. If we can pull that off in 2014 and find the money to do that, we're going to save a lot of money down the line. We're hoping then 2 years later to have an abort test as well. And that's, I think, a pretty reasonable program. It's obviously going to depend on what the budget is in the out years and so forth. But, that's, we're

pretty excited about having EFT–1. Charlie approved that, and that has got us pretty pumped up.

Mr. CABANA. And, Senator, if I could add to his comments also—it will allow us, the recovery folks at KSC, the launch and recovery folks down there that will be retrieving this vehicle, to develop the procedures that they need to recover it, and it will prepare them better for the future also.

Senator BOOZMAN. Good. Very good. Thank you very much. That's very helpful.

Senator NELSON. I just want to underscore what you all said, because a lot of people miss the significance of this in all the detail.

We're talking about a test flight of the Orion capsule that is for the big rocket. And this test flight will go in two Fiscal Years. We're in Fiscal Year 2012 right now, and we're talking about Fiscal Year 2014 for this test. And for those who are concerned about launching rockets down at the Space Center, in addition to what's going on with the commercial rockets, then we're talking about the big rocket, developmental program and test program, starting as early as 2 years from now.

So, thank you for bringing that clarity to this issue.

What obstacles do you think there are on future partnerships that you all have talked about? For example, Mr. Cabana, you talked about Space Florida, the Boeing company utilizing the Orbiter Processing Facility number 3.

Do you see any legal obstacles or other obstacles in the future partnerships? As you were saying, you've got two more OPFs. You'd like to utilize those, instead of them just sitting there.

Mr. CABANA. Yes, sir. It's going to be a challenge, Senator. When we have a single facility that we can turn over to someone to use, it's much easier than if we have a joint use facility. If we're truly going to make the Kennedy Space Center Launch Complex 39 a multiuser spaceport, where we run into issues is when we have a government program and a commercial program, for example, both operating out of the vehicle assembly building, rolling out to the pad, and we get into cross-waivers, the liability, and who's responsible, and how much do you pay?

When you turn a facility over, it's pretty clear what the O&M costs on that facility are. When you have joint use of a facility and somebody's only in there a small portion of the time, for example, how do you charge their fair share?

But, I don't see any obstacles that we can't work through. We're making progress. Nothing is ever easy. But, you know, we are going to make it work. So, we'll figure it out as we go. I promise you, if issues come up that we need help on, we'll make sure that we go to the right folks to get that help, sir.

Mr. LIGHTFOOT. And, Senator, I would add that, you know, the Michoud Assembly Facility down in New Orleans is part of the Marshall Space Flight Center, and we've been going to the, similar efforts in bringing folks in to use Michoud to help lower our costs as an agency.

And it is, sometimes it can be difficult to make sure we're doing the right thing and bringing the right folks in to maintain that capability. But, we're all kind of learning from each other as we go

through these processes to make sure we get the right tenants in to utilize those facilities and share those costs.

Senator NELSON. Mr. Lightfoot, as we develop this big rocket that we're referring to here as the SLS, can you elaborate on what other uses there might be for the SLS vehicle beyond NASA's Human Exploration Program? How much of a priority is it for you to find other users of the SLS?

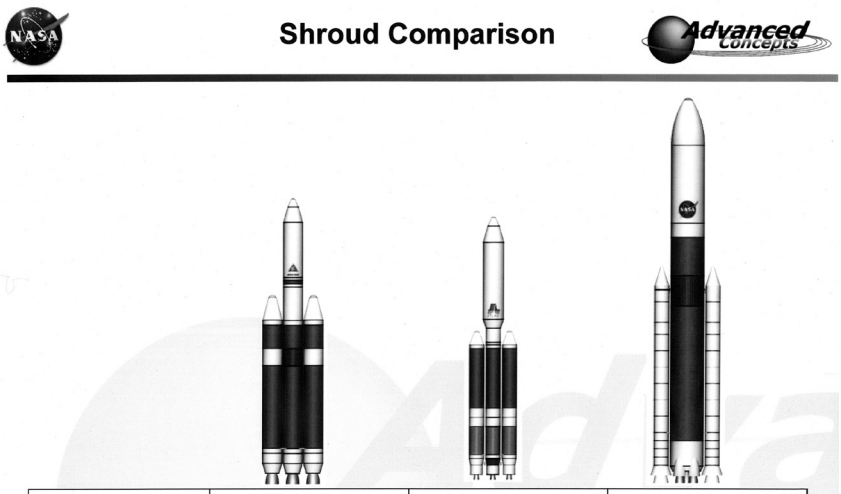
Mr. LIGHTFOOT. Well, we, as an Agency, are talking about that now. We have a couple teams in place that are looking at other missions that the rocket could do. And it's more than the lift capability. It's a lot to do with the volume. This is going to be a large volume as well in the payload area.

We've talked to, we are continuing to——

Senator NELSON. Describe that for the people that are listening in the audience on television right now. How big—take, for example, what's the diameter of the current, let's say, the commercial rockets? And then, describe the diameter of the big rocket.

Mr. LIGHTFOOT. I don't have the commercial ones in the top of my head. We can get you that for the record.

[The information on the rockets follow:]



	Delta IV HLV	Atlas V HLV	SLS
Usable Volume (ft^3)	8,244	8,244	40,000
Diameter (ft) Fairing/Core	16.4/16.4	16.4/12.5	27.6/27.6
LEO Payload (mt)	23 - 25	29	70/105/130
Liftoff Thrust (M-lbf)	1.95	2.58	8.29

But, I know the big rocket, I believe most of them are 5 and a half meters, 18 feet. It's the largest—we're talking 27 and a half foot in our first version, and a potential to go to 33 feet in the upscaled version, and 130 metric tons. So, it's a lot more volume. And, again, so it's more than just the mass. It's the volume.

So, we're talking to our science community on what, how could we use that rocket for that potential, any potential missions they have down the road, as well. And have the Government agencies, and even commercial folks, in terms of letting them know what that capability is.

Senator NELSON. Have you had any discussions with potential users of that much larger volume?

Mr. LIGHTFOOT. Yes. We've talked to them. But it's been, you know, very speculative at this point. It's a lot of this, you've got to get it built, and we'll take advantage of it when it gets there.

Senator NELSON. From your perspective, the commercial approach, such as used by companies as SpaceX and Orbital, and now Boeing is in that competition as well, versus the government approach to launch vehicle development—describe for us the differences in your mind, particularly as it pertains to cost. And how do these approaches differ?

Mr. LIGHTFOOT. Well, I think for us on the government side, we have a set of standards we follow and we do as part of the U.S. Government, especially in relation to how we buy those capabilities.

The commercial guys, we're actually learning some things from them in terms of what they've been doing, and spending some time with them. I think every one of us have been to the commercial guys to see how they're doing it and what they're doing. And they have some things they can do as a commercial entity we can't do as the Government in terms of how they purchase things.

But, for the most part, I think what we bring to the table is, we have a legacy and a history—not that they don't. I mean, they're perfectly capable and have some great folks as well. But, we're pulling on our legacy and history. But, we're also starting to poke on our legacy and history, to make sure we're not overdoing things, so that we can get back into the affordability arena in a better way.

We have taken, I know, on the SLS we've taken some, I want to say, 170 "shall statements" we had in our documents, and we've knocked them down to around 25. And we're making things fight their way back in. At, trying very hard not to compromise any safety, you know, because that's critically important for us, but recognize where we may be putting a requirement out there that we can be a little bit more relaxed on than we have in the past. And that, and we're looking at each one of those, one at a time. So, that's how we're looking at it, as it relates to us versus the commercial guys.

Senator NELSON. So, both approaches are trying to learn from each other.

Mr. LIGHTFOOT. I think so. We're, a lot of our workforce, a lot of, all the agencies' workforce in individual places are, we have 80-something Space Act Agreements—I think Bob said he had over 80—where we're helping other entities with specific capabilities that we have in our shop, to help them work some of the issues they're dealing with as they go through the development process as well.

Senator NELSON. Mr. Coats, the Administrator mentioned in his testimony that Orion has streamlined its insight and oversight model. How has this streamlining saved NASA on development cost? And what about the lessons learned to be applied to larger programs?

Mr. COATS. Well, one of the outcomes of the last 20 months of uncertainty, when we weren't quite sure if we were going to have an Orion program of any kind, the Administrator had told our team to continue marching on until we got that resolved. But, be-

cause of the series of continuing resolutions, the budget was very constrained for the last 20 months. So, we have had to look for ways to achieve efficiencies, if you will. And we've had excellent results, I think, working with Lockheed Martin, a contractor who I used to work for—as full disclosure here.

But, I think we've learned a lot about working together and looking for ways to eliminate redundancies, inefficiencies; look for the cheapest way to get testing done, whether it's acoustic testing, vibration testing, whatever. What's the best way to get that done? We had no choice. We had to revisit all of the requirements that we had laid out, you know, all the "shall statements" that we had in our documents, and so forth—were they really necessary? Because that adds money to the program.

We've talked about insight and oversight. We've looked at ways to streamline that. I think we've got an excellent working relationship right now with the contractor. If we can do the testing that we've laid out, that we talked about previously, EFT–1 and then the abort test and so forth, I think we've got a good test program laid out here and, which will mitigate and allay all the risks that we're worried about in the program right now.

I'm really proud of the team. And they've been doing, they've marched on while Charlie was saying, we're going to resolve this. And he did in May. He made that decision. We've continued on with the testing. We did the pad abort testing. We did the impact testing last year, and the—or, last week in the Langley hydrolab down there.

So, we haven't stopped the testing that we've been doing. It's been stretched out a little bit because of the budget uncertainties. There's no question about that. There has been an impact to the schedule. But, the team has really stayed focused. And I have to give a lot of credit to the team, to the contractor team and frankly, the senior NASA management for pressing on. And all this was clarified by Congress and the Administration.

Senator NELSON. And, on lessons learned, Director Cabana, what adjustments have you made to the management of the Commercial Crew Program as a result of input from the industry and lessons learned from the Commercial Cargo Resupply Program?

Mr. CABANA. I think one of the biggest changes is, if you look at previous NASA programs, they're very civil service intensive, a large number of FTE. The Commercial Crew Program that we share jointly with the Johnson Space Flight Center has very few—under 200 civil servants working on it.

I think that we used the, we've looked to the launch services program, which has done very well procuring vehicles for our science missions, and how they do their work. I'm not saying we can go as far in that direction as they have. We're trying to find that middle ground that is less restrictive, or, intensive in many ways as previous procurements, and, to, an easier way of doing it, that allows this give and take between the government and the contractor to come to the right answer.

Requirements are a big deal. When we talk commercial space, first off, everybody talks commercial space and how different it is. It's a government procurement by a different name. All our vehicles have been built by commercial companies. So, it's a little bit

different way of doing things. And hopefully it will be a less expensive way of doing things that will get what we want out of it when we define our requirements.

And that's the key, is, we go to a fixed price contract—we have to firmly define what our requirements are, and not change them, because every change brings huge costs. So, I think if we put the work into it on the front end, firmly define our requirements, as Director Coats has said, we will be able to get to an answer that provides the vehicle that we need, with the proper insight, and is safe, and allows our crews to fly on it to the International Space Station in a less costly manner.

Senator NELSON. Senator, do you have anything else?

Senator BOOZMAN. No. Thank you, Mr. Chairman. Again, this has been a very helpful hearing, I think, for all of us.

Senator NELSON. Indeed, it has.

Thank you, gentlemen.

The meeting is adjourned.

[Whereupon, at 11:57 a.m., the hearing was adjourned.]

A P P E N D I X

Additional Information Submitted by NASA in Response to Question and Answer Period with Senator Boozman

NASA shares the belief of its current and potential partners that challenging and exciting exploration missions will be international in nature, so the Agency is actively engaging with the international community, facilitating efforts to collaboratively set the stage for human exploration missions of the future through both the ISS partnership and in the International Space Exploration Coordination Group (ISECG). Agencies are looking for near-term opportunities to coordinate and cooperate that represent concrete steps toward enabling the future of human space exploration across the solar system. Formal partnerships for exploration preparatory activities are being discussed with several agencies where mutual interest and benefit has been identified. These are partnerships in the areas of advancing exploration technologies, robotic missions and the use of ISS. Formal partnerships related to human exploration missions will follow, when appropriate, but the timing of such partnerships is highly content dependent and cannot be predicted at this time. NASA and its international space agency colleagues will continue their work to understand common goals, objectives, and approaches to satisfy them.

Response to Written Questions Submitted by Hon. Bill Nelson to Hon. Charles F. Bolden, Jr.

Question 1. Over the past 2 years, there has been much debate within NASA, the Administration, and the broader space community concerning NASA's priorities and direction. What portions of the debate do you consider settled, and what questions do we still need to answer? How are you working to move the agency forward in a unified direction?

Answer. NASA's detailed plans are described with the FY 2013 budget request. In more general terms, NASA is working to execute the balanced program of space exploration agreed to by the President and a bipartisan majority of Congress within a constrained budget environment.

We are working to send humans to an asteroid and ultimately to Mars, to peer deep into space to observe how the first galaxies form, and to broaden human activity in low-Earth orbit (LEO). We have completed assembling and outfitting of the U.S. segment of the International Space Station (ISS), allowing us to focus on full utilization of the Station's research capabilities. NASA is making air travel safer and more efficient, learning to live and work in space, and operating a fleet of spacecraft to investigate the Earth, the Solar system and the Universe.

The FY 2013 request supports the implementation of key priorities for NASA.

First, since the historic construction of the International Space Station (ISS) was completed in 2011, and now that all the international partners have agreed to its extension to at least 2020, we must enhance its utilization to ensure the success of this national laboratory. For over eleven years, international crews of space explorers have been living on orbit, both building the International Space Station and conducting a diverse research program continuously. NASA is committed to making this National resource available to the broader scientific and commercial research community. Key to its sustainment is the availability of a U.S. commercial crew and cargo delivery capability as soon as possible. NASA is working with American companies to establish the next generation of safe and efficient vehicles for access to LEO and the ISS. In calendar year 2012, we will see the first commercial cargo flights to the ISS, demonstrating the innovation and capabilities of our industry partners and providing a path forward to end our sole reliance on Russian transport of astronauts. We will continue to work with our industry partners to develop end-to-end systems for transporting crew and cargo to orbit. I am committed to ensuring that American companies, launching from U.S. soil, are providing the cargo and crew transportation services that we need to keep the ISS functioning. We are mak-

ing steady progress on these launch services. Later this spring and summer, we expect that both of our private company partners, SpaceX and Orbital Sciences, will complete demonstration flights of their cargo vehicles to Station and actually berth with the ISS, marking a major milestone in our goal to establish commercial space capabilities for low-Earth orbit travel. Some modification of the Iran, North Korea, Syria Non-proliferation Act (INKSNA) provisions will likely be required for the continued operation of ISS and other space programs after 2016. The Administration plans to propose appropriate provisions and looks forward to working with the Congress on their enactment.

Second, with the FY 2013 budget request, NASA is moving out on plans to develop a flexible launch system that will ultimately be the most capable in history. The Space Launch System (SLS) rocket and the Orion Multi-Purpose Crew Vehicle (MPCV) will carry American astronauts beyond low-Earth orbit and into deep space within the next decade. Following a thorough analysis of alternatives, NASA has established architecture for SLS and the Orion MPCV. In recent months we have continued to push forward with contracting and design efforts to make this system a reality. At the same time, we are moving forward on a critical effort to develop the technologies and capabilities required to support our ambitious exploration goals. Our FY 2013 budget request supports our plans for an uncrewed SLS test flight in 2017 and a crewed test mission by 2021.

Third, we plan to continue progress toward the launch of the world's most advanced telescope in 2018. The James Webb Space Telescope (JWST) will operate deep in space to orbit the sun nearly one million miles from Earth. From that vantage point, JWST will look out into space and back in time almost as far as it is possible to look. Over the past year, NASA has engaged in a thorough review of JWST, made important adjustments to management, and put the project on a sound financial footing. Since we completed this new plan, the project has met 19 of 20 FY 2011 milestones (with one deferred without impact), and has met all FY 2012 milestones to date on or ahead of schedule. NASA is confident that the FY 2013 request supports a 2018 launch of JWST.

Fourth, the FY 2013 budget request supports continued advances in new space technologies. The National Research Council (NRC) has determined that future U.S. leadership in space requires a foundation of sustained technology advances, but that the U.S. space program is now living on the innovation funded in the past. Our focus on new space technologies is absolutely essential to enable NASA to achieve its ambitious goals. At the same time, NASA technology research seeds innovation, supports economic vitality and helps to create new jobs and expanded opportunities for a skilled work force. Space technology investments address long-term Agency technology priorities and technology gaps identified by NASA Mission Directorates and within the Agency's draft space technology roadmaps. On February 1, 2012, the NRC released its final review of NASA's Draft Space Technology Roadmaps. The report, which notes that NASA's technology base is largely depleted and identifies sixteen top-priority technologies necessary for NASA's future missions, which also could benefit American aerospace industries and the Nation. This NRC assessment will help guide NASA's technology priorities in the years to come.

NASA's budget request supports a portfolio of innovative science missions that will explore the diverse planetary bodies of our solar system, unravel the mysteries of our universe and provide critical data about our home planet. Currently operating missions continue to return a stream of data from orbits around the Sun, Mercury, the Moon, the asteroid Vesta, Mars, and Saturn. We now have missions on the way to Jupiter, Pluto and Mars. Sixteen Earth Science missions in orbit study the Earth as an integrated system. The Hubble, Spitzer, Chandra, and Fermi space telescopes continue to make groundbreaking discoveries on an almost daily basis. In calendar year 2011, the *Messenger* spacecraft entered orbit around Mercury, Ebb and Flow began mapping the gravity field of the Moon, and Juno launched on its way to Jupiter. Also in 2011, Aquarius produced the first global view of ocean surface salinity and the Suomi National Polar-orbiting Partnership satellite began making observations of Earth's weather and climate. In 2012, we will launch the Nuclear Spectroscopic Telescope Array to study massive black holes, supernovae and other high-energy sources in the universe, and will launch the Radiation Belt Storm Probes into Earth's Van Allen belts. In 2013, we will launch the next land observing mission (the Landsat Data Continuity Mission) and complete environmental testing of the Global Precipitation Measurement mission, the Lunar Atmosphere and Dust Environment Explorer (LADEE) and the Mars Atmosphere and Volatile Evolution (MAVEN) mission.

In view of these key priorities for NASA and of our constrained fiscal environment, we will not be moving forward with the 2016 and 2018 ExoMars missions we had been studying with the European Space Agency. Instead, NASA is developing

a new, integrated strategy for Mars missions to ensure that the next steps for Mars exploration will support science and human exploration goals and take advantage of advanced space technology developments. NASA will complete this integrated plan, including the framework for a mission to take advantage of the 2018 or 2020 launch opportunities, no later than this summer and, hopefully, in time to support the FY 2013 appropriations process. The FY 2013 request supports this approach, and this process will be informed by coordination with the science community and our international partners. The FY 2013 budget request continues to support robust Mars exploration including two spacecraft orbiting Mars, the Opportunity rover on the surface, a multi-year exploration of Mars by the Curiosity Mars Science Laboratory, and the MAVEN mission to explore the Mars upper atmosphere. The August landing of Curiosity will be among the most difficult technical challenges that NASA has ever attempted and Curiosity's mission of exploration will far eclipse anything humanity has attempted on the surface of Mars in the past. We look forward to receiving a treasure trove of data from the surface of Mars to help answer questions about its past and present habitability.

With the 2013 request, NASA will conduct aeronautics research to enable the realization of the Nation's Next Generation Air Transportation System (NextGen), and the safer, more fuel efficient, quieter, and environmentally responsible aircraft that will operate within NextGen. Through the aeronautics research we conduct and sponsor with universities and industry, NASA helps to develop the technology that enables continuous innovation in aviation. As a result, U.S. companies are well positioned to build on discoveries and knowledge resulting from NASA research, turning them into commercial products that benefit the quality of life for our citizens, provide new high-quality engineering and manufacturing job opportunities, and enables the United States to remain competitive in the global economy.

The request also continues NASA's dedicated efforts to inspire the next generation of explorers. NASA can provide hands-on experience and inspiration as few other agencies can. To foster the development of the U.S. work force, NASA's education programs will focus on demonstrable results and capitalize on the Agency's ability to inspire students and educators through unique missions and the big challenges that help today's young people envision their future in science, technology, engineering and mathematics (STEM). NASA Education is one of many Federal Government programs that support STEM education. NASA Education is working with other agencies through the National Science and Technology Council's Committee on STEM Education to fund coordinated and effective student and teacher opportunities. NASA will focus its resources on demonstrated areas of strength in its unique role in STEM education, freeing resources for other Agency priorities. NASA brings many assets, beyond funding, to support the Administration's emphasis on STEM education. Our people, platforms like the International Space Station, and our facilities across the Nation all contribute to strengthening STEM education.

Question 2. We continue to see the characterization of a heavy lift capability as a competing priority with a commercial crew capability—with strong advocacy by some for one at the exclusion of the other. Please explain why these capabilities are complementary and why we need both.

Answer. NASA, with its commercial and international partners, has embarked on a new phase of human space exploration and development—one that will be supported by commercial crew transportation to low-Earth orbit (LEO) and by the development of the Orion Multi-Purpose Crew Vehicle (MPCV) and the heavy-lift Space Launch System (SLS), which will enable missions beyond LEO. This split between commercial and Government systems allows for a cost effective approach to promote a broad base for human exploration by the United States.

In LEO, the International Space Station (ISS) has entered its operations and research phase, and this phase will continue through at least 2020. A robust transportation architecture is critical to ensuring full utilization of this research facility—including research efforts that will support the development of long-duration exploration missions beyond LEO. Private enterprise and affordable commercial operations in LEO, including the transportation of crew to and from ISS (as well as rescue from ISS), will enable U.S. industry to support NASA and other Government and commercial users safely, reliably, and at a lower cost. NASA is helping to lay the groundwork for the emerging LEO space economy as we also end our sole reliance on Russian transport of astronauts to the ISS.

The commercial crew and cargo systems that support ISS will enable NASA to focus its internal development efforts on the Orion MPCV and SLS, which will send U.S. astronauts on missions of exploration beyond LEO. These systems will be flexible enough to support many different mission scenarios, and will serve well in the decades to come. The Orion MPCV and SLS launcher will provide NASA with the flexibility to conduct missions to a variety of compelling destinations beyond LEO,

including Near-Earth Asteroids (NEAs), the Moon, the moons of Mars, and Mars itself.

Question 3. How can efforts, such as NASA's recent MOU with the Air Force and NRO on launch vehicle certification bring down the cost for space access government-wide? What other possibilities is NASA considering for partnering with the national security community to reduce costs?

Answer. NASA supports the addition and use of new entrants in all classes of launch vehicles in order to continue to facilitate and encourage competition, which will be the true motivator for reduced launch service prices over the long term. The Coordinated Strategy for Certification of New Entrant Launch Vehicles recently signed by the U.S. Air Force, National Reconnaissance Office (NRO) and NASA is anchored in NASA's existing model and policies. The Strategy provides a common framework for jointly communicating with industry and providing alternatives to mitigate the inherent risk of any new launch system. The Strategy should enable more companies to become certified to launch high value robotic payload missions and thus further enable future competition amongst commercial launch service providers.

NASA and the national security community have a long history of cooperation. While the national security community and the Nation's civil space agency have different missions, priorities, and budget allocations, there are many similarities. For example, NASA shares with the national security community many of the same technologies, enabling systems, facility and workforce needs, and a common industrial base. The key to cooperation and a fruitful partnership is to focus on the activities that advance the needs of both organizations and result in potential efficiencies and cost savings.

Through groups such as the Space Industrial Base Council and now the Defense Production Act Committee, NASA partners with the national security community to address industrial base challenges. NASA also participates with the national security community in industry forums such as the Space Quality Improvement Council and the Space Supplier Council to work with industry to improve how we acquire space systems with the ultimate goal of improving affordability and mission success. NASA is currently working with our national security partners and the Department of Commerce to periodically survey the industrial base to improve our understanding of industry and its supply chain. This effort has the potential to reduce costs in several ways: By identifying commonality within supply chains across agencies and programs we can reduce procurement and asset management costs and facilitate common specifications and standards that can lower production costs. We can also work with other agencies to mitigate supply chain risks and identify and resolve issues before they become major (and costly) problems *e.g.,* parts and material shortages, counterfeit parts, and the loss of skills, capabilities, product lines, and/or suppliers.

A particular focus area for NASA's interagency industrial base activities has been in propulsion. The Department of Defense (DoD) has been invited to participate in the recently announced initiative called the National Institute for Rocket Propulsion Systems (NIRPS). Led by the Marshall Space Flight Center, NIRPS is establishing a forum for cooperation, collaboration, information sharing, and alignment of common pursuits to better manage investments across portfolios to ensure the industrial base can sustain those critical technologies and skills in the liquid propulsion sector, which in turn will hopefully drive down the costs of propulsion systems. NASA is also engaged in other active partnership efforts with DoD, such as Eastern range modernization activities under the 21st Century Space Launch Complex initiative as well as ocean recovery support for the Orion MPCV.

Question 4. What is the path forward for the creation of more formal international partnerships for exploration? When would these agreements need to be in place?

Answer. NASA shares the belief of its current and potential partners that challenging and exciting exploration missions will be international in nature, so the Agency is actively engaging with the international community, facilitating efforts to collaboratively set the stage for human exploration missions of the future through both the ISS partnership and in the International Space Exploration Coordination Group (ISECG). Agencies are looking for near-term opportunities to coordinate and cooperate that represent concrete steps toward enabling the future of human space exploration across the solar system. Formal partnerships for exploration preparatory activities are being discussed with several agencies where mutual interest and benefit has been identified. These are partnerships in the areas of advancing exploration technologies, robotic missions and the use of ISS. Formal partnerships related to human exploration missions will follow, when appropriate, but the timing of such partnerships is highly content dependent and cannot be predicted at this

time. NASA and its international space agency colleagues will continue their work to understand common goals, objectives, and approaches to satisfy them.

Question 5. When will we start development of the additional elements we need for exploration missions, such as landers and deep space habitats?

Answer. In the near term, NASA is focusing its exploration development efforts on the Orion MPCV and SLS—foundational capabilities that will be required for all contemplated deep space destinations. Several technology and capability development activities will also produce systems and subsystems that are required for deep space human exploration missions, such as a Deep Space Hab, new space suit, etc. The goal for longer lead technology efforts is to demonstrate new capabilities by 2020 to enable human missions in the next decade.

NASA is pursuing a capabilities-driven architecture approach to human spaceflight exploration planning, which in turn drives the system development and technology prioritized investments. Architecture and analysis efforts are ongoing, to include continuing studies on initial destinations for the first test flights of the Space Launch System (SLS) and Orion Multi-Purpose Crew Vehicle (MPCV) as the basic elements of the system. The SLS and Orion MPCV are being designed to provide capabilities for a variety of deep space missions to multiple destinations including the Moon, asteroids, the moons of Mars, and ultimately the surface of Mars. Besides near-Earth asteroid rendezvous flights, these systems could be used to support circum-lunar navigations and flights to Earth-Moon Lagrange points. Lagrange points are gravitationally stable regions created by the interaction of the gravity fields of any two large masses; an object placed at Lagrange point will tend to stay in place for a long time. These could therefore be excellent locations in which to place habitation modules to study long-duration expeditions away from LEO, conduct developmental systems tests, enable tele-robotic operations, and execute science activities. Beyond this initial capability, SLS and Orion MPCV could support eventual missions to the moons of Mars—Deimos and Phobos and the surface of Mars itself, with incremental upgrades. In addition, NASA has been working with the National Research Council (NRC) to develop Technology roadmaps for the Agency. Much like the Science decadal surveys, these roadmaps will help guide the Agency's investment strategy to ensure NASA is advancing the technology it needs for future human exploration. These roadmaps will help inform Agency decisions about the specific timeframes for the development of additional elements needed for exploration missions.

In further support of such development the Human Exploration and Operations Mission Directorate's (HEOMD) Advanced Exploration Systems (AES) Program is pioneering new approaches for rapidly developing prototype systems, demonstrating key capabilities, and validating operational concepts for future human missions beyond Earth orbit. Early integration and testing of prototype systems will reduce risk and improve affordability of exploration mission elements. The prototype systems developed in the AES program will be demonstrated in ground-based test beds, field tests, underwater tests, and flight experiments on the ISS. Many AES projects will evolve into larger integrated systems and mission elements that will be tested on ISS before we venture beyond Earth orbit. The AES Program is developing a deep space habitat, a crew excursion vehicle, reliable life support systems, advanced spacesuits, radiation protection, and autonomous systems to assist the crew with mission operations. The AES Program is also developing a small lunar lander test bed and technologies for autonomous precision landing. The Space Technology Program is developing capabilities for cryogenic propellant storage, in-space propulsion, power generation and energy storage, and advanced robotics. The goal is to demonstrate these new capabilities to enable human missions in the next decade.

The AES and the Space Technology Programs will work closely together to incorporate and integrate new technologies and innovations as they are matured to the point of infusion.

Question 6. A human mission to Mars would be extremely difficult, if not impossible, with what we know about the effects of such a mission on the human body and our current abilities to mitigate those effects. How is NASA addressing this issue and what confidence do we have that NASA's research and technology programs will make such a mission possible? How is NASA pursuing advanced propulsion technologies that could significantly shorten the trip to Mars, such the VASIMR engine?

Answer. NASA recognizes the significant life and health sciences challenges associated with long-duration human spaceflight beyond the protection of Earth's Van Allen radiation belts. As such, NASA is pursuing a comprehensive program across multiple fields of research and applications-based areas of study including radiation, micro- and partial-gravity, among others. The HEOMD International Space Station

(ISS) Program, Space Life and Physical Sciences Research and Applications (SLSPRA) Division, and Human Spaceflight Capabilities Division, with the office of the Chief Health and Medical Officer, are among the organizations focused upon solutions to the challenges of human space exploration.

One of the key roles played by the ISS is that of exploration research laboratory. Experiments being conducted on the ground and aboard ISS will help scientists understand, and engineers mitigate, the negative impacts of extended exposure to the microgravity environment on the human body. Such impacts include decalcification of bones, muscle atrophy, and radiation exposure. NASA is refocusing the Human Research Program within SLPSRA to ensure a coordinated, systematic approach to risk reduction. The development of technologies and techniques to counter these effects is critical to deep-space missions.

NASA also recognizes that any future human exploration effort is largely dependent on developing breakthrough technologies that will enable astronauts to safely go farther and faster into space and at a lower cost. By investing in high payoff, breakthrough technologies that industry does not have today, NASA matures the technologies required for future missions, while proving the capabilities and lowering the cost of government and commercial space activities. The Agency has identified several high-priority technologies to support human exploration of Mars, including long-term storage and transfer capabilities for cryogenic fluids; solar electric propulsion for efficient in-space transportation of cargo; nuclear thermal propulsion to reduce interplanetary trip time for the crew; entry, descent, and landing technologies to land large payloads on Mars; and deep space habitation systems that incorporate advanced life support and radiation protection. The Advanced Exploration Systems and Space Technology Programs are developing these capabilities for future human missions. The Variable Specific Impulse Magnetoplasma Rocket (VASIMR) is one example of electric propulsion technology that may hold promise for future deep space missions.

Question 7. Please provide a detailed list of milestones for the next year for both SLS and Orion.

Answer. Please see below.

November 2011

- *11/1—Space Launch System (SLS)* Stages Justification for Other than Full and Open Competition posted
- *11/4—SLS, MPCV, Ground Systems Development and Operations* (formerly 21st Century Ground Systems) Formulation Authorization Documents signed
- *11/8—SLS* Engine (RS–25) Justification for Other than Full and Open Competition posted; *Orion* Boiler Plate Test Article Phase I Water Drop Test #3
- *11/9—SLS* J–2X E10001 Test Fire (500 seconds)
- *11/14—SLS* Industry Day at Michoud Assembly Facility
- *11/17—Orion* Periodic Technical Review 3
- *11/21—SLS* Key Decision Point A Decision Memo signed
- *11/30—GSDO* Mission Concept Review; Mobile Launcher Structural Load Test Completed

December 2011

- *12/1—SLS* Engine Undefinitized Contract Action Issued; Orion Boiler Plate Test Article Phase I Water Drop Test #4; *SLS* J–2X E10001 Test Fire (80 seconds)
- *12/7—ESD* Cross-Program System Requirements Review
- *12/12—SLS* Advanced Booster Engineering Demonstration & Risk Reduction draft NASA Research Announcement Released
- *12/13—Orion* Boiler Plate Test Article Phase I Water Drop Test #5
- *12/14—SLS* J–2X E10001 Test Fire (100 seconds)
- *12/15—SLS* Advanced Booster Engineering Demonstration & Risk Reduction Industry Day at Marshall Space Flight Center
- *12/16—SLS* Booster UCA Issued; SLS Stages Undefinitized Contract Action Issued
- *12/20—Orion* Main Parachute Test completed successfully
- *12/21—Orion* Exploration Flight Test 1 Undefinitized Contract Action Issued

January 2012

- *1/5—Orion EFT–1* Justification for Other than Full and Open Competition Posted
- *1/6—Orion* BTA Phase 1 Water Drop Test (#6—Final)
- *1/17—ESD* Cross-Program Systems Requirement Review
- *1/31—ESD* Cross-Program Systems Requirement Review Results to Agency and Key Decision Point Approval; *Orion* Crew Module Hardware move to Kennedy Space Center
- *1/25 to 2/3—Orion* Boiler Plate Test Article Modal Test #1

February 2012

- *2/1—*SLS* Advanced Development draft NASA Research Announcement Release
- *2/7 to 2/20—Orion* Boiler Plate Test Article Modal Test #2
- *2/8—Orion* Crew Module Flight Hardware Test Article Tour Complete
- *2/9—**SLS* Advanced Booster Engineering Demonstration & Risk Reduction final NASA Research Announcement Release
- *2/15—SLS* J–2X Power Pack Assembly #2 Test #1—1,9 second spin-start test in Test Stand A–1 at Stennis Space Center
- *2/22 to 2/29—Orion* Boiler Plate Test Article Modal Test #3
- *2/28—Orion* Ground Test Article Test Complete

March 2012

- *3/2 to 3/6—Orion* Boilerplate Test Article Modal Test #4
- *3/6—Space Launch System (SLS)* J–2X Power Pack Assembly Test #2
- *3/8 to 3/12—Orion* Boiler Plate Test Article Modal Test #5
- *3/20—*SLS* Advanced Development final NASA Research Announcement Issued; *SLS* J–2X Power Pack Assembly #2 Test #3
- *3/16 to 3/26—Orion* Boiler Plate Test Article Modal Test #6
- *3/29—SLS* J–2X Engine 10001 with Clamshell in Test Stand A–2 Test #11; SLS System Requirements Review/System Definition Review Step 1 Board

April 2012

- *4/3—SLS* Power Pack Assembly #2 Test #4—*under review*
- *4/9—**SLS* Advanced Booster Engineering Demonstration & Risk Reduction NASA Research Announcement Proposals Due
- *4/12—SLS* J–2X Engine 10001 with Clamshell in Test Stand A–2 Test #12
- *4/17—SLS* J–2X Power Pack Assembly #2 Test #5—*under review*
- *4/19—Orion* Ground Test Article on dock at Kennedy Space Center from Denver
- *4/26—SLS* J–2X Engine 10001 with Clamshell in Test Stand A–2 Test #13

May 2012

- *SLS* J–2X Power Pack Assembly #2 Test #6—*under review*
- *SLS* J–2X Power Pack Assembly #2 Test #7—*under review*
- *SLS* J–2X Power Pack Assembly #2 Test #8—*under review*
- **SLS* Advanced Development NASA Research Announcement Proposals Due
- *SLS* System Requirements Review/System Definition Review Step 2 Board
- *Orion* Crew Module structure shipped to Kennedy Space Center to initiate Assembly, Integration and Production in the Operations and Checkout Building

August 2012

- *Ground Systems Development and Operations (GSDO) System* Requirements Review/System Definition Review Board

* Smaller contract for broader area of risk reduction including, but not limited to, manufacturing, materials, design, operations, etc.

**Limited to Booster risk reduction activities

Question 8. Please characterize the impact on the Commercial Crew Program of the $406 million FY12 funding level per the conference report on H.R. 2112, and

include any relevant assumptions about funding in FY 2013–2018. How will NASA prioritize schedule versus continued funding of multiple competitors?

Answer. NASA performed a reassessment of the acquisition strategy for the next phase of the Commercial Crew Program given the lower than anticipated appropriation of $406M for FY 2012 that was passed by Congress and signed into law by the President. On December 15, NASA announced its decision to modify the competitive procurement strategy. Instead of awarding contracts for the next phase, the Agency plans to use multiple, competitively awarded funded Space Act Agreements. Using competitive Space Act Agreements instead of contracts will allow NASA to maintain a larger number of partners during this phase of the program. NASA intends to structure these Space Act Agreements to provide NASA the flexibility to adjust content and funding levels based on available funds. This flexibility is important during a period of high budget uncertainty when NASA is receiving less funding than President Obama requested for the Agency's commercial space program. This approach for the next phase will facilitate industry's continued development of commercial capabilities but will not require compliance with NASA's certification standards. NASA plans to initiate the competitive process for this next phase in February 2012. NASA still plans to use FAR-based contracts for the certification and purchase of the commercial crew services.

While industry should be able to accelerate their development efforts under SAAs, NASA estimates that the likely availability date of International Space Station (ISS) services missions has likely slipped to 2017 because of the FY 2012 funding level for CCP. This assumes that more robust funding levels will be available in the outyears (FY 2013–FY 2017). Details of the budgetary requirements for this new approach were provided in the FY 2013 President's Budget Request for NASA.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. MARIA CANTWELL, TO HON. CHARLES F. BOLDEN, JR.

Question 1. What is your rationale for the initial use of the 5-segment solid rocket boosters on the Space Launch System rather than holding an immediate competition for the final advanced booster?

Answer. NASA is moving out with the development of the Space Launch System (SLS), having announced the basic architecture of the system on September 14, 2011. The NASA Authorization Act of 2010 (P.L. 111–267, October 11, 2010) directed the Agency to develop, as rapidly as possible, replacement vehicles capable of providing both human and cargo launch capability to destinations beyond low-Earth orbit. In general, it can take anywhere from 6–8 years to develop a heavy lift launch vehicle; however, NASA is expediting that process by utilizing as much existing hardware as possible. In developing the SLS, the Act directed the Administrator to utilize, to the extent practicable, existing contracts, investments, workforce, industrial base, and capabilities from the Space Shuttle Program (SSP), Orion, and Ares I projects. This includes SSP-derived components and Ares components that draw extensively on SSP heritage propulsion systems, including liquid fuel engines, cryogenic stages, and solid rocket motors. As a result, the Agency will initiate the development of the SLS with SSP- and Ares-derived assets. The Agency presently is undertaking full and open competitive procurement activities for the SLS Advanced Booster. Initial steps in this process have been taken (please see response to Question #2).

Question 2. My understanding is that in the press call after the September Space Launch System announcement, NASA Associate Administrator for Human Exploration and Operations Bill Gerstenmaier stated that the advanced booster competition for the Space Launch System would take place "almost immediately." We are now hearing that the competition will take place possibly in 2015 after some low-level risk reduction study contracts are completed. NASA's plans are simply unclear. What is the timing and process planned for the advanced booster competition?

Answer. NASA plans to compete the SLS Advanced Booster, and has already taken the initial steps in this process:

- The Agency posted a draft NASA Research Announcement (NRA) for "SLS Advanced Booster Engineering Demonstration and/or Risk Reduction" on December 12, 2011.
- An Industry Day focused on the SLS Advanced Booster Engineering Demonstration and/or Risk Reduction activity was held at Marshall Space Flight Center (MSFC) on December 15, 2011.

- NASA issued the final NRA for SLS Advanced Booster Engineering Demonstration and/or Risk Reduction on February 9, 2012, with responses due back to NASA on April 9, 2012.

The NRA solicits applied research proposals, which will offer solutions to meeting the Advanced Booster goal of reducing risk in the areas of affordability, performance, and reliability. Specifically, the NRA solicits proposals that will: (1) provide an Advanced Booster concept in response to a set of top level performance requirements; (2) identify liquid and/or solid booster high risk areas; (3) provide related hardware demonstrations on how risk can be mitigated; and (4) identify high risk areas associated with adaptation of Advanced Booster technology to SLS. NASA has identified potential target areas for risk mitigation. However, other high value demonstration proposals for liquid or solid rocket designs for target areas beyond those specifically identified are requested.

This NRA effort is important in order to ensure that NASA will be able to evolve the SLS from its initial 70-metric-ton capability to the final 130-metric-ton capability, which will enable a variety of human missions to deep-space destinations. The NRA phase for the Advanced Booster is anticipated to be 30 months. NASA anticipates initiating a full and open competitive Design, Development, Test and Evaluation (DDT&E) procurement for the Advanced Booster system in FY 2015 with contract award anticipated in FY 2016.

Question 3. What specific steps are being taken to prevent giving the current Space Launch System booster contractor an unfair advantage in the future advanced booster competition?

Answer. The Advanced Booster performance requirements are significantly greater than the current booster contractor's configuration provides to NASA, therefore a new development is required in some manner whether the final concept uses solid or liquid propellant. In addition, the SLS Program is again engaging industry early in the acquisition process to ensure requirements and the solicitation are written to maximize competition. Potential offerors have been asked for their comments first in a Request for Information issued in October, then through the comment process on the draft NRA, and have also been invited to sit one-on-one with the proposal evaluation team. Second, a detailed technical library is being provided to maintain competitiveness across all potential offerors. Finally, the evaluation criteria in the solicitation have been thoroughly reviewed within the Agency to ensure the best solicitation to yield competitive proposals and an equitable evaluation.

Question 4. How is NASA ensuring that the core vehicle and the launch pad are being designed and built to handle both liquid and solid rocket booster options? What are the added costs involved in following the current path rather than simply holding the advanced booster competition immediately?

Answer. The system (and core) design process includes an analysis of multiple alternatives that include both liquid and solid booster options. Concept studies are determining the effect of both designs on the core vehicle with worst-case structural loads and thermal environments used to derive ultimate vehicle design requirements. In order to minimize launch facility development costs, the SLS Program and 21st Century Ground Systems Program are collaborating on pad design to account for base heating effects and vehicle hold-down design, while holding the vehicle configuration to two boosters but providing flexibility of booster design diameter.

The current SLS Program development approach entails executing an immediate, albeit two-phased, advanced booster competition. An advanced booster that meets exploration requirements to lift 130 metric tons does not currently exist today. NASA estimates the development timeline of new advanced booster would not support a December 2017 launch. Thus, the approach selected allows phasing of design and development activities (core and upper stages, core and upper stage engines, and spacecraft adapters and fairings) to fit within the yearly budget allocations while mitigating advanced booster development risks, meeting the first flight milestone in 2017 for a 70 metric ton vehicle, and, ultimately, evolving the vehicle to a 130 metric ton lift capacity. The approach exercises good engineering judgment in identifying risks associated with major new concept and/or technology developments before making larger investments in the DDT&E. Additionally, the two-phased approach also allows for vehicle configuration maturation before selecting a final advanced booster concept and provides for early engineering demonstrations/tests, which leverage existing assets to prove the design.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. MARK PRYOR TO HON. CHARLES F. BOLDEN, JR.

Question 1. NASA plans to use five-segment solid rocket boosters for the initial two SLS capability flights through 2021. NASA has announced plans to issue a NASA Research Announcement in December for Advanced Booster Engineering Demonstration and Risk Reduction. NASA has also announced plans to hold an open competition in Fiscal Year 2015 for the SLS Advanced Booster Design, Development, Test and Evaluation (DDT&E) with award anticipated in Fiscal Year 2016. How is NASA ensuring that the core vehicle and the launch pad are designed and built to handle both the initial and advanced booster designs, whether they be liquid or solid rocket booster options?

Answer. In developing an evolvable Space Launch System (SLS) that will grow in capability from lifting 70 metric tons to lifting 130 metric tons, one important challenge is that of integrating the launch vehicle, the spacecraft (specifically, the Orion Multi-Purpose Crew Vehicle [MPCV]), and the supporting launch infrastructure. While NASA does not at this point know whether the SLS Advanced Boosters will use solid or liquid propellant, the Agency will define specific booster-to-core-vehicle electrical, physical, and thermal interfaces and interoperability requirements to ensure that potential bidders to the Advanced Booster contract announcement will be fully apprised of the requirements to which they must design their systems. By defining these interfaces and requirements for potential bidders, NASA will ensure that the SLS core vehicle and associated infrastructure will be able to accommodate liquid or solid rocket booster designs, as long as these designs are based on the Agency's requirements.

Question 2. What are the added costs involved in following the current path rather than holding the advanced booster competition immediately?

Answer. The NASA Authorization Act of 2010 (P.L. 111–267, October 11, 2010) directed the Agency to develop, as rapidly as possible, replacement vehicles capable of providing both human and cargo launch capability to destinations beyond low-Earth orbit. NASA is expediting the development process by utilizing as much existing hardware as possible. In developing the SLS, the Act directed the Administrator to utilize to the extent practicable existing contracts, investments, work force, industrial base, and capabilities from the Space Shuttle Program (SSP), Orion, and Ares I projects. This includes SSP-derived components and Ares components that draw extensively on SSP heritage propulsion systems, including liquid fuel engines, cryogenic stages, and solid rocket motors. As a result, the Agency will initiate the development of the SLS with SSP and Ares derived assets. This approach will enable NASA to flight test the SLS with the Orion MPCV sooner than would be possible if the Agency were to first go through the process of developing requirements for a brand new Advanced Booster and holding a design competition. NASA anticipates that the utilization of existing technologies for the initial SLS capability will speed development of the system and reduce overall system development cost for the initial capability. NASA presently is undertaking full and open competitive acquisition activities for the SLS Advanced Booster. Initial steps in this process have been taken:

- The Agency posted a draft NASA Research Announcement (NRA) for "SLS Advanced Booster Engineering Demonstration and/or Risk Reduction" on December 12, 2011.
- An Industry Day focused on the SLS Advanced Booster Engineering Demonstration and/or Risk Reduction activity was held at Marshall Space Flight Center (MSFC) on December 15, 2011.
- NASA posted the final NRA for SLS Advanced Booster Engineering Demonstration and/or Risk Reduction on February 9, 2012, with responses due back on April 9.

The NRA solicits applied research proposals, which will offer solutions to meeting the Advanced Booster goal of reducing risk in the areas of affordability, performance, and reliability. This effort is important in order to ensure that NASA will be able to evolve the SLS from its initial 70-metric-ton capability to the final 130-metric-ton capability, which will enable a variety of human missions to deep-space destinations. The NRA phase for the Advanced Booster is anticipated to be 30 months. NASA anticipates initiating a full and open competitive Design, Development, Test and Evaluation (DDT&E) procurement for the Advanced Booster system in FY 2015 with contract award anticipated in FY 2016.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. MARK WARNER TO HON. CHARLES F. BOLDEN, JR.

Question 1. The commercial crew program will be funded at $406 M for Fiscal Year 2012, a lower amount than the Administration's request. What is NASA's plan to accelerate expansion of commercial crew to prevent sending hundreds of millions of dollars overseas to competing programs? Will NASA consider using the proven successful model of Space Act Agreements again to expedite these private sector developments?

Answer. NASA performed a reassessment of the acquisition strategy for the next phase of the Commercial Crew Program given the lower than anticipated appropriation of $406M for FY 2012 that was passed by Congress and signed into law by the President. On December 15th, NASA announced its decision to continue to use multiple, competitively awarded funded Space Act Agreements for the next phase. Using competitive Space Act Agreements instead of contracts will allow NASA to maintain a larger number of partners during this phase of the program. NASA intends to structure these Space Act Agreements to provide NASA the flexibility to adjust content and funding levels based on available funds. This flexibility is important during a period when NASA is receiving less funding than President Obama requested for the Agency's commercial space program.

The announcement for proposals was released on February 7, 2012. These competitively awarded SAAs are expected to be followed by a competitively awarded contract for the certification phase. The certification phase will ensure that the designs fully meet the safety and performance requirements for NASA utilization.

Question 2. The Commercial Orbit Transportation Services (COTS) model delivered capabilities at a fraction of the cost that traditional NASA acquisition would have been. Given the constrained budget environment for NASA going forward, this model is incredibly valuable. Can you provide information on how NASA will look to implement the value and cost-savings obtained from the public-private partnerships utilized in the commercial programs in other programs?

Answer. As noted in the response to Question #1, NASA will be using competitively awarded SAAs for the next phase of its Commercial Crew Program, though the certification phase of the Program is expected to proceed under a competitively awarded contract.

A decision to work with or support others outside the Agency (including commercial partners) to fulfill Agency goals or objectives requires NASA to review the relevant authorities available to implement the decision. The options could encompass several alternatives, such as procurement contracts with industry and universities, interagency agreements, or international cooperation. The Agency may also provide financial and/or technical assistance to others in the form of grants, cooperative agreements, or SAAs to foster activities that support the Agency's overall mission when that mission can be met by advancing a public purpose instead of acquiring property or services for the direct benefit or use of NASA. The Agency also has the authority to enter into other types of arrangements depending on the circumstances, such as leases, concession agreements, property loan agreements, and Cooperative Research and Development Agreements (CRADAs), for example. NASA must take into account the opportunities and limitations presented by each option when it formulates its approach, as each authority is subject to its own set of related laws, regulations, and policies.

Question 3. Thank you for giving me a brief update on NASA's plans at Wallops Island, Virginia. Can you provide more detail on what you believe the potential for Wallops is in terms of commercial space generally, and the commercial crew program? What role will Wallops play as you progress with commercial crew, and how do you plan to partner with the private sector? Can you provide any details on plans for furthering developing infrastructure at Wallops?

Answer. The Commercial Crew Program (CCP) is a partnership between NASA and the private sector to incentivize companies to build and operate safe, reliable, and cost effective commercial human space transportation systems. In the near term, NASA plans to be a reliable partner with U.S. industry, providing technical and financial assistance during the development phase. In the longer term, NASA plans to be a customer for these services, buying transportation services for U.S. and U.S.-designated astronauts to the ISS. NASA hopes these activities will stimulate the development of a new industry that will be available to all potential customers, including the U.S. Government.

Regarding the use of Wallops Island, Virginia for potential inclusion in commercial crew transportation systems, NASA does not plan to dictate the use of any specific ground infrastructure by any commercial provider. The commercial provider will own and operate the crew transportation systems, and the commercial providers

will decide which launch site and what ground infrastructure they plan to use. NASA's interest will be in ensuring that whatever site/infrastructure is chosen, that it will be safe, reliable, and cost effective.

An example of a commercial entity that has expressed interest in using Wallops' capabilities is Orbital Sciences Corporation, which Wallops and the Mid-Atlantic Regional Spaceport for launching its Antares rocket. Orbital has a Space Act Agreement with NASA to conduct demonstration flights under the Commercial Orbital Transportation Services (COTS) effort, as well as a contract with NASA to launch supplies to the ISS under the Agency's Commercial Resupply Services (CRS) effort. In addition, Orbital is pursuing other launch activities using the Antares from Wallops for NASA science and technology payloads, as well as for other Government agencies and commercial organizations.

Question 4. NASA has now decided on an architectural plan for its next space launch vehicle, and has offered cost and schedule estimates for its completion. In the past, we've seen cost grow, schedules slip, and projects run on a cost-plus basis. How are you working to prevent that kind of cost growth in the Space Launch System?

Answer. Moving forward on the SLS, one of NASA's greatest challenges will be to reduce the development and operating costs (both fixed and recurring) for human spaceflight missions to sustain a long-term U.S. human spaceflight program. The Agency must plan and implement an exploration enterprise with costs that are credible and affordable for the long term.

NASA appreciates the work of Booz Allen Hamilton on the Independent Cost Assessment (ICA) for the SLS, Orion Multi-Purpose Crew Vehicle (MPCV), and the Exploration Ground Systems (formerly named 21st Century Ground Systems). The ICA recommendations provide advice on the effective and efficient implementation of NASA's programs given the technical and architectural decisions that have been made. The Agency has already implemented a number of recommendations, and will continue to carefully consider the remainder of the ICA's findings and recommendations as it proceeds to implement these efforts during its program formulation activities.

NASA is currently assessing a number of potential opportunities for reducing the institutional costs associated with developing, producing, and operating SLS. For example, NASA continues to partner with other Federal Government and commercial customers to maximize utilization of the rocket test facilities at SSC. United Launch Alliance and the U.S. Air Force already utilize test stand capabilities there, including the B1 test stand for RS–68 testing and the E-Complex for component and small-thrust testing. NASA is currently considering other potential opportunities for sharing capabilities.

In addition to prudent consolidation of infrastructure, the SLS Program will continue to examine ways to increase efficiency and agility to deliver an affordable and achievable heavy-lift system as soon as possible. Examples being considered in formulating SLS plans include the following:

- Using common parts and common designs across the Government to reduce costs;
- Ensuring requirements are appropriately specific and also that requirements applied to NASA crew launch vehicles are similar to those provided to our eventual commercial crew partners, thereby ensuring that NASA vehicles are not required to meet more substantial requirements than commercial crew vehicles, and vice versa;
- Conducting insight/oversight activities of the Agency's contract partners in a smarter way, thereby using NASA's resources more appropriately to focus on the high-risk items; and
- Ensuring that there are no unique configurations or developments that do not end up directly supporting the final system.

Once a final SLS architecture decision is made, NASA will develop detailed plans to accomplish these goals and will keep Congress apprised.

Question 5. NASA has publicly stated that the Space Launch System cannot meet the 130 metric ton legal requirement without advanced boosters. The first unmanned test launch in 2017 could provide the desired reentry trajectory for the Orion MPCV by using the upper stage and no boosters. Can you provide a status update and timeline on plans for an advanced booster competition?

Answer. NASA plans to compete the SLS Advanced Booster, and has already taken the initial steps in this process:

- The Agency posted a draft NASA Research Announcement (NRA) for "SLS Advanced Booster Engineering Demonstration and/or Risk Reduction" on December 12, 2011.
- An Industry Day focused on the SLS Advanced Booster Engineering Demonstration and/or Risk Reduction activity was held at Marshall Space Flight Center (MSFC) on December 15, 2011.
- NASA posted the final NRA for SLS Advanced Booster Engineering Demonstration and/or Risk Reduction on February 9, 2012.

The NRA solicits applied research proposals, which will offer solutions to meeting the Advanced Booster goal of reducing risk in the areas of affordability, performance, and reliability. Specifically, the NRA solicits proposals that will: (1) provide an Advanced Booster concept in response to a set of top level performance requirements; (2) identify liquid and/or solid booster high risk areas; (3) provide related hardware demonstrations on how risk can be mitigated; and (4) identify high risk areas associated with adaptation of Advanced Booster technology to SLS. NASA has identified potential target areas for risk mitigation. However, other high value demonstration proposals for liquid or solid rocket designs for target areas beyond those specifically identified are requested.

This effort is important in order to ensure that NASA will be able to evolve the SLS from its initial 70-metric-ton capability to the final 130-metric-ton capability, which will enable a variety of human missions to deep-space destinations. The NRA phase for the Advanced Booster is anticipated to be 30 months. NASA anticipates initiating a full and open competitive Design, Development, Test and Evaluation (DDT&E) procurement for the Advanced Booster system in FY 2015 with contract award anticipated in FY 2016.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KAY BAILEY HUTCHISON TO HON. CHARLES F. BOLDEN, JR.

Question 1. During the hearing, you and I had an exchange regarding a question I posed regarding the issue of establishing the appropriate development budget planning for the Space Launch System. It appeared to me there was some apparent misunderstanding or miscommunication regarding the precise nature of the question, resulting in an incomplete or unclear response. The issue and concern prompting that question is of such importance that some follow-up is necessary, and useful to provide an opportunity for greater clarification for the hearing record. The question, I believe, is fairly straightforward but I will restate it perhaps more clearly, and with the background that prompts it.

The context for the question was the meeting in my office on September 13th of this year, with Jack Lew, Director of the Office of Management and Budget, Rob Nabors, and yourself and your Deputy Administrator, along with Senator Nelson and members of our respective staffs. The purpose of that meeting was to have a definitive discussion with Mr. Lew on the Administration's position regarding the selection of the reference design for the Space Launch System (SLS) as required by the 2010 NASA Authorization Act (P.L. 111–267). Mr. Lew indicated that after serious and thorough consideration, the Administration had made the decision to support the development of SLS following the basic reference vehicle design presented in the Ninety-Day report provided to the Congress the previous January 10th. He indicated that it was clearly going to be a challenge to identify and provide resources to support that development, but that he was committed to work with the Congress to do so and meet the letter and intent of the law with regard to that development. That welcome news was matched by a commitment by Senator Nelson and myself to make our best efforts, in working with NASA and Administration officials, to achieve those objectives. Contrary to what you indicated during the hearing, there was no specific discussion of funding levels or capability milestones during the meeting and thus none were agreed to, beyond the broad commitment to jointly seek to ensure the development could proceed—obviously, from my point of view, as outlined in the legislation.

Prior to that meeting, the Committee had been informed of the data provided to the Booz Allen corporation in late June to enable it to conduct an independent assessment of the cost basis for what had been determined by you, I understand, on June 22 as the proposed reference vehicle design, and which had formed the basis for that portion of the NASA FY 2013 budget submission then under development. That was, of course, *prior to a formal Administration decision to support the vehicle design selection.* The budget profile presented for review at that time, and as provided to the Committee, reflected a $1.3B annual funding level for the procurement

portion of the development activity. (With the addition of personnel costs and other associated ground support costs, etc., the combined total annual funding level would be roughly $1.8B annually, but the focus was on the procurement portion of the activity, and I referenced that number, as the only number formally available to the Committee at that time other than the number in the FY 2012 Budget Request, which of course had yet to be dispositioned by the Congress at that time.)

My question was and still is, simply stated, the following:

Given the "official" notification by Mr. Lew in our meeting of a decision to proceed with the SLS vehicle development on September 13, and the commitment to seek to identify the necessary resources to successfully pursue that development in a manner meeting the requirements and objectives of the law, would it not make sense to expect that the Agency would be provided the opportunity to revisit its FY 2013 budget submission, now "armed" with that commitment, and make the case for a modification of the "pre-decisional" budget profile in a manner that might more closely achieve at key aspect of the statutorily-described capabilities of the SLS? Namely, that the core elements of the evolvable SLS vehicle design would be available (the law described a "goal" of December 31, 2016) to provide backup crew and cargo launch capability to service the ISS in the event either commercially-developed capabilities or international partner-provided capabilities might not be active or available at that time. Clearly, the pre-decisional profile reviewed by Booz-Allen, with a cargo capability available by end of 2017 and a crew capability not available before 2021, would not meet that required capability, especially with respect to crew capability, since that would not be available until after the end of the currently-committed period of U.S. utilization and support of ISS through the year 2020.

Answer. As provided previously, the President and I are committed to ensuring America's continued preeminence in launching a new era of human space flight that takes us beyond where we have ever gone before. NASA shares Congress' goal of sustaining U.S. leadership in space exploration and is committed to implementing the SLS that Congress authorized in the NASA Authorization Act of 2010. Our exploration systems and the scientific and technical advances produced by the ISS, in concert with timely development of our critically important commercial crew and cargo capability, support NASA's long-term exploration program. SLS and Orion MPCV without commercial crew and cargo and vice versa would leave a critical void in our human and robotic exploration program.

The SLS reference vehicle design that was selected last year was the result of thorough analyses based upon stakeholder requirements that were levied upon the Agency. Among the requirements included using existing hardware and contracts to the maximum extent practicable to minimize development costs and schedule. After conducting this analysis, the Agency decided to use the current reference vehicle design. Based on our estimates for development, manufacturing and testing of the reference vehicle design, the first flight is scheduled to occur in 2017. Additional funding would not accelerate this schedule, however it would increase the confidence that the schedule could be met. NASA is assessing the option of accelerating the first crewed flight currently scheduled for 2021 given the Agency's projected funding profile. As part of the FY 2014 budget formulation process, NASA will be analyzing the technical and budgetary feasibility of accelerating the flight.

As a result of the current fiscal environment, NASA's appropriation in 2012 was $1.8 billion below the authorized level, and $700 million below the 2011 level. In this context, resources allocated to the development of our human exploration vehicles must be balanced as part of the larger portfolio of programs and projects supported by NASA, and authorized by—and with appropriations from—the Congress. The President's Budget Request for FY 2013 would fund the Orion MPCV at $1.02 billion, and the total SLS request of $1.885 billion, which includes $1.34 billion for the SLS vehicle development plus $404.5 million for Exploration Ground Systems (EGS) which had previously been carried under the SLS line, in addition to $140.4M of SLS and EGS related construction of facilities. EGS will develop all of the necessary launch site ground systems to enable the assembly, testing, and launch of the SLS elements. The funding related to construction of facilities will be used to modify test and launch facilities in support of the SLS launch vehicle.

Question 2. During the hearing, both in response to the question repeated above, and in response to other questions raised by Members, you stated "I don't have more money. I'm not going to get more money." As an expansion on my previous question, can you state for the record the basis for that statement? Subsequent to the meeting on September 14, were you provided, or did you request, an opportunity to demonstrate the need for "more money" in order to advance the development milestones for SLS in a manner more consistent with the objectives of the law? If so, was either that opportunity denied, or if you were able to make the case for increased funding, was that denied? I recognize that you could perhaps be instructed that the answer

to such a question might be precluded on the grounds of internal Administration "pre-decisional" discussions. However, what I am asking about relates to a conversation held with the Director of the Office of Management and Budget, and goes to the heart of whether the degree of willingness to materially support the SLS development with adequate resources to meet prescribed Congressional preferences and intent changed as a result of that conversation. A negative response or a refusal to respond will not inspire confidence that the commitment to "work together to find adequate resources to successfully develop the SLS" as made in that meeting, should be considered a credible commitment.

Answer. As previously noted, NASA is committed to the development of the SLS. Our budget formulation for 2013 was guided by the Congressional guidance provided in the NASA Authorization Act of 2010 and taking into account the 2012 Appropriation reductions from that. Our analysis of SLS funding requirements resulted in the final funding level requested for SLS vehicle development supported by the separate funding lines requested for EGS and Construction of Facilities. While the specifics of the budget formulation process are pre-decisional, as the question suggests, NASA has worked closely with OMB on the development of the President's FY 2013 budget request for the Agency. The requested funding will enable the Agency to develop, test and launch the SLS and Orion MPCV first uncrewed flight in 2017 and the first crewed flight in 2021. Concurrently, the Agency continues to aggressively pursue cost-savings initiatives to increase schedule confidence and robustness and reduce development costs. The SLS, Orion MPCV and EGS programs have already initiated several affordability efforts including streamlining government oversight and insight, incrementally building and testing vehicle capabilities, reducing the number of contractor formal deliverables, and streamlining processes while maintaining adequate rigor.

Question 3. In response to a question from Senator Rubio during the hearing, you indicated that one of your responsibilities was to live within your budget. I certainly cannot disagree with that. However, would you also agree that one of your responsibilities, in service to the President, and as NASA Administrator, is to tell the President directly what budget your Agency would need to more faithfully execute the Congressional Act, which he signed into law? Would you agree that such a conversation with the President is within the scope of your prerogatives as a direct appointee of the President, and cannot be precluded or over-ridden by conflicting guidance from the Office of Management and Budget or any official of that Office?

Answer. Yes, such conversations are within the scope of my prerogatives as a Presidential appointee and I have had discussions with the President and his staff about priorities. While the intent is to continue to implement the direction given in the Authorization Act, the timing of that implementation must be dependent on the funding annually appropriated by the Congress and within the constraints of realistic outyear planning in a tight fiscal environment.

Question 4. Given the fact that the SLS, certainly in its initial development phase, will be using mostly technology, systems and infrastructure that are well-known and understood, I assume we should not expect any major delay to development of the full vehicle because of technology challenges. Would you agree with that, and, if not, would you provide your rationale for the technical challenges you believe impose significant challenges for the development schedule of the SLS?

Answer. Per direction in the NASA Authorization Act of 2010 (P.L. 111–267), NASA is using existing contracts in the development of SLS to the extent practicable. NASA does not anticipate significant technical challenges in the development of the SLS, but it should be noted that this approach, while sound, does not eliminate all potential technical challenges. The use of existing technologies in a new vehicle necessitates the integration of different systems, and this integration poses technical challenges. In addition, in seeking to provide the most effective boosters for the SLS, NASA is planning to compete the advanced boosters for the SLS. On December 12, 2011, the Agency released a draft NASA Research Announcement for Advanced Booster Engineering Demonstration and/or Risk Reduction, with the final NRA anticipated to be released in February of 2012. The advanced boosters could be solid or liquid, and the amount of off-the-shelf content used is to be determined. NASA will work to ensure that any technical challenges are resolved expeditiously and that the SLS schedule milestones are met.

Question 5. Is it accurate to assume that the 2017 date for the first operational un-crewed flight of the SLS and Orion Multi-Purpose Crew Vehicle together, and the first flight with crew in 2021are dates that—especially the 2021 date—could be moved sooner in time if adequate or additional funding were made available? Please provide documentation supporting your response.

Answer. NASA's plans include an uncrewed system test flight of the Orion and SLS in 2017, and a crewed test flight in 2021. It is important to note that while the availability timeframes of these vehicles could potentially be impacted by increased funding, the development of the spacecraft, the launch vehicle, and the supporting infrastructure must be carefully coordinated so that all three elements will be operationally available at the same time. In planning the development and integration schedules of Orion, SLS, and Exploration Ground Systems (EGS) efforts, NASA has worked to ensure that the flow of resources would support this goal.

NASA is currently conducting an integrated technical, schedule, and cost review, which will be completed late this summer. The results of this review will help NASA assess the degree to which it might be possible to accelerate the crewed SLS/Orion MPCV test mission, currently scheduled for 2021.

Question 6. As you know, we experienced considerable frustration over the past year waiting for a final decision and announcement on the SLS vehicle design. We now have the consensus and agreement we were seeking. However, the Committee continues to have its oversight responsibility so I want to be sure you understand that we will continue to want the regular updates we have been receiving *and to be made aware of any issue that might come up that could cause a delay in moving forward.* Will you and your senior program officials continue to supply the Committee with biweekly updates on the SLS and Orion?

Answer. NASA recognizes and welcomes its responsibility to keep the Congress informed of the progress of its efforts, and senior program officials look forward to continuing to provide the Committee with biweekly updates on SLS, Orion, and EGS, as well as any issues that could cause a delay in moving forward.

Question 7. At the SLS Industry Day held at the end of September in Huntsville, NASA officials discussed plans for contract modifications for Core and Upper stage, Avionics, and Boosters. For those elements of the SLS where current contracts can be used and simply modified as needed to redirect work toward SLS activities, can you provide the status of those contract discussions? Is work now taking place under those revised contracts? If so, would you please describe that work in your answer to these questions?

Answer. Since the SLS architecture announcement in September 2011, NASA has taken numerous procurement actions consistent with Agency planning. An SLS acquisition strategy overview was released on September 22, 2011. This overview defined the procurement plans to utilize existing assets to expedite development, as well as further development of technologies and future competitions for advanced systems and key technology areas specific to SLS evolved vehicle needs. This general synopsis was followed by specific synopses announcing NASA's intent to pursue Justifications for Other than Full and Open Competition (JOFOCs) to use the existing Upper Stage contract for the SLS Stages (including the Core and Upper Stages) and to use the existing J–2X engine contract for the SLS Upper Stage Engines and Core Stage Engines. To gain efficiencies, it was determined that the avionics effort will be incorporated into the Stages contract scope. The current booster contract will be utilized for the use of for five-segment solid rocket boosters for the initial SLS missions.

Following the release of these statements, NASA authorized SLS work to begin under undefinitized contract actions (UCAs) for Stages, Engines, and Boosters pending negotiation of final contract modifications for these efforts. A UCA combining the efforts of the RS–25D and J–2X engines was issued on December 1, 2011. A UCA for the Space-Shuttle-derived solid rocket boosters to support initial design and development efforts and supply boosters for the first two test flights was issued on December 16, 2011. A UCA for SLS Stages (Consisting of the Core Stage, Upper Stage and Avionics) was issued on December 16, 2011. The UCAs permit NASA and the contractors to perform critical and urgent work on SLS while the contracts modifications are definitized through the summer and fall of 2012. This includes continued testing of the J–2X, shipping of RS–25D engines to Stennis Space Center for qualification and testing, initial design and testing of the Core Stage structure, and preparations for the first five-segment solid rocket motor qualification test in 2013.

In addition, on December 12, 2011, a draft NASA Research Announcement (NRA) was released for the Advanced Booster Engineering Demonstration and Risk Reduction and Development contracts. On December 15, 2011, the NRAs were openly discussed in an Industry Day at Marshall Space Flight Center, which was attended by over 64 different potential bidders. The SLS Program held separate meetings with many of the bidders to obtain feedback on the Draft NRAs to improve the final release product. The final NRA was issued in February 2012.

Question 8. As you know, I am keenly interested in the full utilization of the Space Station, especially the portion designated as a U.S. National Laboratory. The Committee has included language in each Authorization Act since 2005 to help guide the establishment of the ISS as a national laboratory, and to ensure it meets clear policy and process objectives intended by the Congress and in a manner best defined last year in the "Reference Model for the International Space Station U.S. National Laboratory," a study commissioned by NASA and published in September of 2010. You mention this new relationship briefly in your statement, but can you describe, in detail, how this partnership will work between NASA, the space station operations management, and the independent non-profit entity that will manage the National Laboratory? Please include a description of any deviation from either the submitted—and accepted—proposal provided by CASIS, or the subsequent Cooperative Agreement between NASA and CASIS, and the relevant explanation, justification and supporting documentation for any such deviation.

Answer. Following the direction of the NASA Authorization Act of 2010 (P.L. 111–267), proposals were solicited in early 2011, and in 2011, the Center for the Advancement of Science in Space (CASIS) was awarded a cooperative agreement to manage the non-NASA use of the ISS National Laboratory. As the cooperative agreement states, CASIS will work with NASA to expand utilization of the ISS and to develop new sources of investment in ISS research through the use of innovative management tools. The relationship between NASA and CASIS will be such that CASIS can execute its responsibilities as defined in the cooperative agreement independently of NASA. CASIS will be judged on its performance of the tasks they agree to with NASA, as documented in the annual program plan. Space station operations management will execute the research that CASIS brings forward, in a manner similar to research currently executed for the International Partners.

There are differences between the CASIS proposal and the methods in which the cooperative agreement is being performed, but these changes are not unusual for cooperative agreements. CASIS has filled several key positions with individuals other than those identified in the original proposal. Several positions have also been modified or added; the Director of External Affairs and the Director of Development positions have been replaced by the Director of Community Engagement, Public Relations, and Communication, and a Director of Economic Valuation and a Director of Marketplace Development have been added. In addition, CASIS brought several functions in house that were originally proposed to be performed by subcontractors, most significantly the performance dashboard and project valuation methodologies that are proprietary to Pro Orbis LLC, one of the partners identified in the CASIS proposal. However, these personnel and subcontracting decisions have been discussed with NASA and are within the discretion of the recipient of a grant or cooperative agreement, per NASA's regulations as found in 14 CFR Part 1260. CASIS has also proposed to establish an Economic Collegium to provide economic and business advice, analogous to the function of the Science Collegium in scientific and technical issues. While not described in the proposal, the Economic Collegium appears to be a reasonable concept, and NASA has no objections to this development.

Another departure from the CASIS proposal in the method used to appoint the permanent board of directors. The CASIS proposal described a Board consisting of ex officio members including the Chairs and Ranking Members of NASA's House and Senate authorizing committees, the NASA Administrator, and senior officials from Federal agencies active in research and development. Staff from the Office of Science and Technology Policy and the Office of Management and Budget, together with the NASA Administrator, would have been tasked with selecting candidates for the Board.

However, Federal employees serving in the specific roles contemplated by the bylaws issued by CASIS under Florida law would need to exercise fiduciary responsibilities prohibited by 18 U.S.C. §208, a Federal statute on conflicts of interest. After considering the merits of governance structure, NASA management determined that even non-fiduciary board positions by Federal officials would represent an inappropriate level of Federal involvement in CASIS' internal governance. However, NASA is very much in accord with the intention of the original proposal to ensure that the experience of key Federal stakeholders is applied to assist CASIS in recruiting a balanced and skilled board. NASA is working with Executive and Legislative branch stakeholders to define an alternative Board process and structure that will provide a broad venue for Federal input into CASIS' board selection, while at the same time providing CASIS with appropriate latitude to meet its governance obligations under the cooperative agreement. This work is still underway, but significant progress has been made. NASA will keep Congress apprised of developments.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN BOOZMAN TO HON. CHARLES F. BOLDEN, JR.

Question 1. Human exploration beyond Low Earth Orbit requires some common elements, such as a heavy lift rocket like the Space Launch System and an ascent and descent spacecraft like Orion. Other elements such as in-space propulsion, space exploration vehicle, and long duration habitat have been said to be required for astronauts to perform meaningful exploration missions. When might such elements be expected to be designed, built, and used? Are there other elements besides these which might be required? When would they be proposed and in what time-frame might they be expected to come on line?

Answer. NASA is pursuing a capabilities-driven architecture approach to human spaceflight exploration planning, which in turn drives the system development and technology prioritized investments. Architecture and analysis efforts are ongoing, to include continuing studies on initial destinations for the first test flights of the Space Launch System (SLS) and Orion Multi-Purpose Crew Vehicle (MPCV) as the basic elements of the system. The SLS and Orion MPCV are being designed to provide capabilities for a variety of deep space missions to multiple destinations including the Moon, asteroids, the moons of Mars, and ultimately the surface of Mars. Besides near-Earth asteroid rendezvous flights, these systems could be used to support circum-lunar navigations and flights to Earth-Moon Lagrange points. Lagrange points are gravitationally stable regions created by the interaction of the gravity fields of any two large masses; an object placed a Lagrange point will tend to stay in place for a long time. These could therefore be excellent locations in which to place habitation modules to study long-duration expeditions away from low Earth orbit (LEO), conduct developmental systems tests, enable tele-robotic operations, and execute science activities. Beyond this initial capability, SLS and Orion MPCV could support eventual missions to the moons of Mars—Deimos and Phobos and the surface of Mars itself, with incremental upgrades. In addition, NASA has been working with the National Research Council (NRC) to develop Technology roadmaps for the Agency. Much like the Science decadal surveys, these roadmaps will help guide the Agency's investment strategy to ensure NASA is advancing the technology it needs for future human exploration. These roadmaps will help inform Agency decisions about the specific timeframes for the development of additional elements needed for exploration missions.

In further support of such development, and consistent with NASA's technology roadmaps, the Human Exploration and Operations Mission Directorate's (HEOMD) Advanced Exploration Systems (AES) Program is pioneering new approaches for rapidly developing prototype systems, demonstrating key capabilities, and validating operational concepts for future human missions beyond Earth orbit. Early integration and testing of prototype systems will reduce risk and improve affordability of exploration mission elements consistent with the capabilities-driven exploration architecture. The prototype systems developed in the AES program will be demonstrated in ground-based test beds, field tests, underwater tests, and flight experiments on the ISS. Many AES projects will evolve into larger integrated systems and mission elements that will be tested on ISS before we venture beyond Earth orbit. The AES Program is developing a deep space habitat, a crew excursion vehicle, reliable life support systems, advanced spacesuits, radiation protection, and autonomous systems to assist the crew with mission operations. The Space Technology Program is developing capabilities for cryogenic propellant storage, in-space propulsion, power generation and energy storage, and advanced robotics. The goal is to demonstrate these new capabilities by 2020 to enable human missions in the next decade. The AES and the Space Technology Programs will work closely together to incorporate and integrate new technologies and innovations as they are matured to the point of infusion.

Question 2. NASA Exploration will undoubtedly be aided by research conducted in low earth orbit to develop and test technologies as well as operational concepts. What type of exploration-related research is currently planned and how exactly does the International Space Station fit into NASA's exploration plans? Also, how crucial, and in what capacity would the Commercial Resupply Service and the Commercial Crew Program be in facilitating a successful Exploration Program?

Answer. The ISS is vital element of NASA's science and technology development effort to enable safe, affordable, and sustained human exploration of deep space. As NASA's only long-duration flight analog for future human lunar outpost missions and Mars transit missions, it provides an invaluable laboratory for research with direct application to the exploration requirements that address human risks associated with deep space missions. The ISS is the only space-based multinational research and technology test-bed available to identify and quantify risks to human

health and performance, identify and validate potential risk mitigation techniques, and develop countermeasures for future human exploration.

The ISS research portfolio includes human research and the development of countermeasures to reduce the deleterious effects of microgravity for long-duration exploration missions. Experiments being conducted on the ground and aboard ISS will help us understand and mitigate the negative impacts of extended exposure to the microgravity environment on the human body. Such impacts include decalcification of bones, muscle atrophy, and radiation exposure. The development of technologies and techniques to counter these effects is critical to deep-space missions. ISS crews are conducting human medical research to develop knowledge in the areas of clinical medicine, human physiology, cardiovascular research, bone and muscle health, neurovestibular medicine, diagnostic instruments and sensors, advanced ultrasound, exercise and pharmacological countermeasures, food and nutrition, immunology and infection, exercise systems, and human behavior and performance.

As a technology development and demonstration platform for exploration, the ISS is currently being utilized to demonstrate advances in life support systems, robotics for crew support and spacecraft servicing, and space-durable materials. NASA is also funding technology development activities that will eventually be demonstrated onboard the ISS such as EVA systems, radiation monitoring, docking systems, and autonomous mission operations. These and other technology development activities are being driven by NASA's overall exploration goals to extend human presence beyond LEO to near-Earth objects (NEOs), and eventually to Mars. NASA is also exploring how the ISS elements and program infrastructure can be utilized to enable or enhance exploration.

A robust cargo and crew transportation architecture is critical to ensuring full utilization of ISS—including conducting the research efforts that will support the development of long-duration exploration missions beyond LEO. The Commercial Resupply Services (CRS) and Commercial Crew Program (CCP) efforts will create and leverage affordable operations in LEO, including the transportation and rescue of crew and transportation of cargo to and from ISS, and will enable U.S. industry to support NASA and other Government and commercial users safely, reliably, and at a lower cost. The commercial crew and cargo systems that support ISS will also enable NASA to focus its own development efforts on the Orion MPCV and SLS, which will send U.S. astronauts on missions of exploration beyond LEO.

Question 3. Recently the International Space Exploration Coordination Group published the Global Exploration Roadmap. This group seems to be an opportunity to form partnerships for exploration which would potentially reduce the burden on the U.S. taxpayer. How does the Global Exploration Roadmap fit within NASA's own Exploration plans? Could it be expected to be of assistance and particular value in a constrained budget situation? How does the recent announcement of the Space Launch System and Multi-Purpose Crew Vehicle position NASA to lead an international team? Do you envision the Global Roadmap leading to international agreements for the purpose of supporting Exploration? Are there any specific elements or systems which NASA is looking to partner on?

Answer. NASA shares the belief of its current and potential partners that challenging and exciting exploration missions will be international in nature. Therefore, the Agency is actively engaging with the international community, facilitating efforts to collaboratively set the stage for human exploration missions of the future through both the ISS partnership and in the International Space Exploration Coordination Group (ISECG). Space agencies, including NASA, are looking for near-term opportunities to coor≥dinate and cooperate that represent concrete steps toward enabling the future of human space exploration across the solar system. In September 2011, the initial version of the Global Exploration Roadmap (GER) was released by the ISECG members. Updates and refinements are planned in 2012. The GER represents a set of scenarios for NASA and the international space agencies to consider as they move forward in defining long-term plans for the exploration of deep space, with a human landing on Mars as the ultimate destination.

The construction and operation of the International Space Station (ISS)—a cooperative venture among the space agencies of the U.S., Russia, Europe, Japan, and Canada—has demonstrated the benefits of collaborating with international partners on large, complex human space projects. The ISS partner agencies and the space agencies of the ISECG are forging future exploration plans and concepts in a multilateral arena, which are strongly guided by NASA's architecture, systems, and mission planning effort. Multiple participants bring a depth of technical expertise, demonstrated capabilities, and funding resources that are vital to our collective success in these challenging endeavors. While the specific partners and their roles in future deep space exploration projects have not yet been defined, NASA anticipates that the human exploration of the solar system will be carried out under an international

effort, with various nations focusing on particular capabilities, and views the ISECG and the GER as important tools in identifying potential future partnerships. NASA's own plans to develop the Orion Multi-Purpose Crew Vehicle (MPCV) and heavy-lift Space Launch System (SLS) are examples of capabilities that the United States will be able to offer to a future international deep space exploration venture. They represent strong foundational capabilities for an international exploration effort and position NASA very well to play a lead role.

Question 4. In your testimony you state that Orion meets the MPCV requirements and that no contract changes need to be made through the development phase of MPCV. In response to my question during the hearing, with regard to when the development phase of the MPCV is expected to be complete, you responded that you would provide that answer for the record. Please do so as a part of your response to these questions.

Answer. NASA determined that Orion met the technical requirements for MPCV, and further determined that the contractual partnership with Lockheed Martin Corporation maps well to the scope of the MPCV requirements outlined in the NASA Authorization Act of 2010 (P.L. 111–267), and the current contract will be used for the development phase of the MPCV. NASA is planning that the Orion vehicle will fly an uncrewed Exploration Mission 1 (EM–1) in 2017 (early FY 2018) and Exploration Mission 2 (EM–2) with a crew in 2021 (early FY 2022).

The Orion Crew Exploration Vehicle (Orion CEV) is being transitioned into the Orion Multi-Purpose Crew Vehicle (Orion MPCV). A thorough contract scope assessment was performed of the suitability of the existing CEV contract with Lockheed Martin. The original contract, Orion CEV Contract NNJ06TA25C, has the flexibility to implement a fully capable beyond-LEO spacecraft. Contract changes occur as required to focus efforts of the contractor, for example on test articles for environmental and loads testing in support of Exploration flights through 2021. The current vehicle development schedule and resulting qualification tests will be completed in FY 2018.

Question 5. Regarding the competition for the advanced booster, what is the planned timeline, from start to finish? How firm are these timelines? In addition, how will NASA ensure that the competition for the advanced booster project will be executed in fair manner? Could you give details regarding these steps?

Answer. A draft Advanced Booster risk reduction draft NASA Research Announcement (NRA) was issued on December 12, 2011. The final NRA was issued on February 9, 2012 as a full and open competition and is expected to result in multiple contract awards for companies to work on risk reduction efforts for advanced booster concepts prior to the actual Design, Development, Test and Evaluation (DDT&E) of the final booster configuration. The SLS Advanced Booster Engineering Demonstration and Risk Reduction acquisition effort will increase affordability, performance, and reliability confidence of an Advanced Booster concept which will enable SLS to evolve to a 130-metric-ton lift capability, and reduce risks for both liquid and solid Advanced Booster concepts. The SLS Advanced Booster will require a significant increase in thrust compared to existing U.S. solid and liquid boosters. The Advanced Booster Engineering Demonstration and Risk Reduction NRA has an anticipated performance period between October 2012 and March 2015. The notional DDT&E contract will be solicited in the 2015–2016 timeframe, after results are received from the risk reduction effort. The SLS Program is targeting the first flight of the Advanced Booster for the third SLS flight in the 2023 timeframe.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. MARCO RUBIO TO HON. CHARLES F. BOLDEN, JR.

Question. Mr. Administrator, I sent you a letter in May about the delayed design plans for SLS and the much delayed workforce transition report. A 2008 appropriations law required NASA to submit this report every 6 months until the next human spaceflight vehicle is fully operational.

Despite not receiving a response to my letter or a plan for releasing the report, I was pleased to see that the latest workforce transition was released in October. However, that was over 2 years since the previous report from July 2009. In the meantime, thousands of Floridians, and aerospace workers around the country, were laid off or forced to move jobs. Yet NASA was not providing an up to date strategy letting these workers know what the agency planned to do. Can you see how this would discourage the space workforce in Florida and at other centers? Moving forward, does NASA intend to update this report every 6 months?

Answer. NASA is committed to keeping the Congress and the workforce apprised of its transition activities. The Agency recognizes that its greatest asset is its peo-

ple—the thousands of individuals across the country in both Government and industry who conceive, design, build, operate, and manage an ambitious program of space exploration on behalf of the Nation. NASA began preparing for Space Shuttle retirement in 2004, and a key part of that effort involved workforce transition. This array of activities included keeping the workforce up to date on the progress of transition, as well as: conducting surveys; matrixing employees; providing training and employee support programs; and working with Federal, state, and local agencies to assist the workforce in developing skills and finding new job opportunities. For example, to help the workforce develop skills and find jobs, the Centers, companies, and workforce organizations have come together to host numerous job fairs (live and virtual) and company showcases with hiring managers; offer extensive training in resume writing, job search skills, and interviewing skills; provide one-on-one counseling; and provide access to resources such as entrepreneur training. In addition, NASA has partnered with departments of Commerce and Labor, Small Business Administration, as well as other organizations to support the work of the Centers, companies, and workforce boards.

In 2009, NASA established the Space Shuttle Transition Liaison Office (SSTLO) in response to direction in the NASA Authorization Act of 2008 (P.L. 110–422). The Agency was directed to assist local communities affected by the termination of the Space Shuttle program by offering nonfinancial, technical assistance to the identified communities and to identify services available from other Federal, State, and local agencies to assist in such mitigation. Specifically, the Office:

- Serves as a clearinghouse by gathering and disseminating information to the affected communities about opportunities available through other Federal, State, and local agencies; and,
- Serves as a key point of contact for the community beyond NASA for information about how the Agency was working with local communities to provide nonfinancial, technical assistance during transition.

While the conclusion of the Space Shuttle Program and the cancellation of the Constellation Program have been very challenging, resulting in the displacement of many skilled, dedicated people, NASA and its industry partners have always endeavored to keep civil service and contractor employees up to date on the status of their programs and transition opportunities.

In terms of keeping Congress apprised of the status of transition efforts, a key component of the *Workforce Transition Strategy* update is the workforce projection table. The period from 2009 to 2011 included a reassessment and reformulation of NASA's human spaceflight program, during which the development of outyear workforce projections was not feasible. In June of 2010, NASA provided Congress with a qualitative white paper covering workforce transition efforts (and in particular, the creation of the SSTLO). In addition, NASA continued to keep Congress apprised of workforce reductions related to the ramp-down of the Space Shuttle Program. NASA provided a *Workforce Transition Strategy* to Congress in September 2011 and will continue to provide updates every 6 months with the next report to be delivered in April 2012.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KAY BAILEY HUTCHISON TO ROBERT D. CABANA

Question 1. In May the administration announced its decision to proceed with the Orion contract and in September it announced its plans and architecture for SLS. Since the announcement of decisions to proceed with Orion and the SLS, what has your Center been able to do that it previously was unable to accomplish?

Answer. With the respective May and September announcements, the Exploration Ground Systems line within the Ground System Development and Operations Program at KSC has transitioned its development focus beyond enabling basic launch facility and systems capability to formalizing conceptual feasibility studies consistent with the SLS and Orion architectures. The GSDO Program conducted a formal Mission Concept Review (MCR) in November to establish ground system mission, needs, goals and objectives that were consistent with the SLS/Orion architectures. Additionally, ground system feasibility trades were evaluated against cost, schedule, technical and schedule parameters. In January, a Key Decision Point (KDP) review was conducted at the Agency Program Management Council (APMC) assessing our MCR results. The APMC and the independent Standing Review Board (SRB) concluded that our concepts were feasible and fit within the required parameters and the Program was formally approved to proceed into formulation and the next KDP.

Question 2. With regard to the announcement of the decision on the Space Launch System, has your employee and contractor workforce become more stable subsequent to that announcement? Are you expecting any more layoffs or major adjustments in workforce?

Answer. Yes the employee and contractor workforce has become more stable and while we expect additional layoffs after completion of Shuttle transition and retirement, the announcement of the architecture and the projected manifest through 2017 and beyond enables higher fidelity planning which will support even greater stability. As for the individuals who were laid off, a number of them have already found employment with other contracts in support of the Orion and Ground Systems Development and Operations programs, as well as with employers across the region and country through our workforce transition efforts.

Question 3. You each represent Centers with historically major responsibilities for human space flight programs. Obviously, there are many capabilities and considerable expertise at NASA Centers throughout the country. Would you please describe the specific steps you are taking to maximize the NASA "Talent Pool", wherever it is physically located, to not only help you fulfill your primary Center Roles, but contribute to the improved efficiency and effectiveness of NASA as a whole?

Answer. The Kennedy Space Center Workforce Planning Office is currently assessing critical skill demands against existing workforce supply (post buyout) to provide senior managers recommendations for optimally utilizing the existing current work force's skills, identify re-training opportunities, and identify unique skill set hiring requirements that can be achieved external to our current work force. These include potential hires from across the Agency and those positions, which can be filled with recent graduates. The Commercial Crew Program is designed to utilize employees at multiple Centers (primarily KSC and JSC), and the Ground Systems Development and Operations Program, SLS, and MPCV programs work closely across KSC, MSFC, and JSC. KSC has always supported details and hires of other NASA Center employees into our workforce and details and hires of our workforce to other NASA Centers.

Question 4. You have recently stated that Kennedy Space Center is to become a multi-user spaceport. With limited resources and facilities what is the operational concept and how will priority be established between programs? How will the Air Force range modernization be factored into your activities—or budget?

Answer. With the reduction in launch manifest from the Space Shuttle to SLS program—coupled with commercial acquisitions of low-Earth orbit transportation (Commercial Orbital Transportation Services (COTS), Commercial Crew Program, etc.)—KSC assets are being made available for commercial use. The multi-user approach will allocate underutilized facilities to these and other commercial providers, and KSC's experienced operations workforce will ensure compatibility between various users. Projected manifests can be supported within available capabilities. If demand grows beyond capabilities, NASA programs will be given priority.

Air Force modernization of the Eastern Test Range remains in the program budget. Working with the 45th Space Wing, targeted projects that enable a robust multi-user spaceport are currently being performed to improve various capabilities on the range. The 21 Century Space Launch Complex (21CSLC) provides funding thru FY2017 to continue NASA priority range modernization projects

Question 5. Can you describe what work needs to be performed on the new Mobile Launch Platform to support the new configuration and weight of the SLS? Can the Crawler and Crawler-way support the overall SLS core and upper stage weight?

Answer. The new Mobile Launcher (ML) will be modified from the previous Ares I "single-stick" configuration to the SLS/Orion configuration, which includes a liquid stage core and various first stage booster options. Under the Constellation program, the structure and basic facility capabilities were completed, but outfitting with ground support equipment (GSE) was canceled during program transition. For SLS/Orion, the ML base structure will undergo significant modifications, the ML tower will receive minor modifications, and new GSE outfitting will be performed.

To support the weight of the SLS/Orion and modified ML, the crawler-way has undergone extensive study and field analysis to verify compatibility with the higher anticipated rollout weight. To support SLS/Orion, one crawler-transporter will be modified and modernized. Design has been performed and modifications have commenced. When complete, the ML and refurbished crawler will support anticipated SLS configurations.

Question 6. What are the current plans for use of Pad 39A? Will it be mothballed or do you anticipate other potential uses?

Answer. Launch Pad 39A is currently being mothballed in the current Space Shuttle configuration. In some cases, to minimize cost to Pad 39B and the new SLS

Mobile Launcher, some Pad 39A systems are being reused. In addition, various commercial users have conveyed interest in Pad 39A for potential NASA, DoD and commercial programs. One commercial user has officially requested "non-exclusive" access in the early 2012 timeframe, and KSC plans to accommodate that request. The commercial launch provider would then be responsible for the operations and maintenance of the systems required for its launch vehicles and any modifications to accommodate those vehicles would be allowed. However, such modifications shall not preclude shared or future use by other commercial or Government users. While concepts are being studied, and other potential users not yet defined, the future configuration of Pad 39A has not been finalized.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. JOHN BOOZMAN TO ROBERT D. CABANA

Question. Can you describe some of the ways you are partnering with industry and the state and federal governments to identify uses for facilities at KSC that are no longer needed in support of Shuttle operations?

Answer. We are working with several different state and local agencies to identify uses for facilities at KSC no longer needed in support of Shuttle operations. These entities include Space Florida, Economic Development Commission of the Space Coast, Brevard Workforce, Florida Department of Transportation, and Florida Department of Economic Opportunity. We are in contact with many companies that would like to utilize some form of the underutilized facility capacity currently available at KSC. These companies also include all of the prospective commercial crew providers. Partnerships, when appropriate, are enacted through Space Act Agreements. One of the most significant examples of these partnerships is the agreement KSC and Space Florida signed to repurpose the Orbiter Processing Facility 3, the Space Shuttle Main Engine Processing Facility and the Processing Control Center for a commercial space customer, the Boeing Corporation, for use in the manufacture and operation of their proposed CST–100 Crew Capsule.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. MARCO RUBIO TO ROBERT D. CABANA

Question 1. Based on current plans, we know that the first SLS test flight is scheduled for 2017, and KSC will have to increase its workforce as we get closer to that launch. Then after that 2017 test flight, the first scheduled mission is set 4 years later in 2021. I am concerned about the time in between flights and potential effects on the KSC workforce. Will KSC maintain its workforce levels during that gap? How will KSC utilize the workforce between the test flight and the first mission?

Answer. The majority of the KSC contractor workforce associated with spaceflight hardware processing during the 2013–2021 time-frame will be under the new Test and Operations Support Contract (TOSC). This contract is being structured to provide processing support to all NASA programs (SLS, MPCV, 21CGS, ISS) performing spaceflight hardware processing at the Kennedy Space Center. Additionally the TOSC is structured to provide flight hardware ground processing, test, integration and launch operations support to other government agencies and commercial customers resident performing work at KSC. It is anticipated that during the 2017 to 2021 timeframe, the TOSC workforce will be supporting multiple NASA, other government agency and commercial entities simultaneously. We are already seeing this scenario emerge with the recent announcement of Space Florida bringing the Boeing Company into Orbiter Processing Facility 3. We are in discussions with multiple other commercial entities to bring their work to KSC and are also in discussions with several DOD entities to bring their programs to KSC. Our initial discussions have identified a growing customer base which will need varying levels of support from supplying simple commodities to full flight hardware processing, test, integration and launch support. Having a broad, multi-customer base performing spaceflight test, processing and operations at KSC will allow the TOSC workforce to be flexibly applied across numerous activities without the need to have a large swing in workforce levels.

The Ground Systems Development and Operations (GSDO) Program has planned a minimal staffing approach that cross-utilizes skills to minimize perturbations between the first test flight and follow-on mission processing flows. The period between the test flight and first operational flight will be focused on the incorporation of lessons learned from the test flight while developing the necessary ground systems and operational capabilities for the first operational flight.

Question 2. We have seen reports in Florida about commercial space entities looking at sites outside of Florida for launch pads. I think this is somewhat understandable given the different entities that launch from Cape Canaveral and the collaboration that goes into the launch schedule. Plus, commercial companies are going to make decisions based on different criteria than NASA, and they are focused on controlling their schedules for their commercial customers. Are you concerned that the factors that go into launching from the Cape could cause commercial entities to look elsewhere where they can have more control over their launch schedules?

Answer. Commercial space providers have many factors that are considered before deciding on the best payload processing and launch site, and each site has unique core capabilities. KSC sees other sites as more of a partnership that can be leveraged to ensure the U.S. has a viable space industry. We believe the Cape has unique capabilities from a 50-year history of launching every American vehicle that carried a crew into space, but we recognize the similarities and differences between the past and the future. KSC has been supporting commercial space activities with our Launch Services Program, using commercial ELV's (Expendable Launch Vehicles) to launch science payloads, and with our Commercial Crew Program, facilitating the development of a U.S. crew space transportation capability. NASA/KSC and the U.S. Air Force (45th Space Wing and Air Force Space Command) are working together to enable the commercial space industry at the Cape by jointly performing a Future State Definition Study. The study will take into consideration NASA and Air Force architectural capabilities, concepts of operations, and enabling policies to increase capabilities, reduce serialization and provide more control over costs. The results will include a prioritized list of investments leading to a more cost effective and customer-focused environment. KSC's goal is to ensure that we meet the partners' requirements for schedule, cost and reliability.

Question 2a. Is there any scenario in which KSC is looking to operate in more of a commercial fashion to meet the launch needs of the industry?

Answer. For every future scenario, KSC believes we must develop more commercially-compatible processes that will be necessary to transform KSC from a government- and program-focused, single-user launch complex to a more capability-centric and cost-effective multi-use spaceport, enabling both government and commercial space providers. NASA and the commercial space customers will work together to develop mutually beneficial agreements that allow for NASA to leverage expertise or to maximize the autonomy of the commercial operation (with minimal oversight) based on the varying needs of the commercial space customers. Streamlined processes will be critical. GSDO, via the 21st Century Space Launch Complex initiative, has already begun implementing necessary infrastructure upgrades for the multi-use launch complex to support both government and commercial space needs. As these users' needs mature, GSDO continues to refine the ground architecture approach and investment strategy for applicability. In parallel, KSC has also already begun transforming our processes for easy access and use of facilities, equipment, and services that maximize flexibility and multi-use concepts.

Question 2b. I know the agencies work together on this, but how can NASA, the Air Force, and the FAA better collaborate to take advantage of the workforce and assets at the Cape to best meet the launch needs of the Nation and retain the skill set and intellectual capital that currently exists on the Space Coast?

Answer. As with any collaboration between different agencies with differing missions that overlap, the potential for improvement exists. NASA, DoD, and the FAA have coordinated well for many years due to the nature of our business. FAA licensing requirements for commercial space activities have fostered close working relationships between FAA, NASA, and the U.S. Air Force (45th Space Wing and Air Force Space Command). Creation of the FAA Technical Center at KSC is one way NASA and the FAA are partnering to try and retain the critical skills for future programs and missions. In working to improve the range, NASA/KSC and the U.S. Air Force (45th Space Wing and Air Force Space Command) are jointly performing a Future State Definition Study to determine a prioritized investment list. NASA is also collaborating with the FAA and they are integrated into the working teams and support the overall management reviews.

Question 2c. First, I want to commend you on your efforts to diversify the mission and capabilities of KSC. Moving forward we know that KSC will play a greater role in technology development for future spaceflight, and some of the workforce that fell under certain programs, like the Shuttle or Constellation, will now be funded under these technology programs. What do you anticipate being KSC's role in technology development for future spaceflight?

Answer. Technology development roles for future spaceflight anticipated for KSC include autonomous control systems, cryogenic and hypergolic fluid storage and

transfer systems, specialized sensor development, specialty materials development (including self-healing corrosion control coatings and self-healing wire insulation), communications, navigation and weather technologies, and novel environmental remediation technologies. KSC is also establishing a pipeline to research, develop and demonstrate hardware and software technologies and capabilities which minimize launch delays/scrubs by avoiding subsystem failures or by detecting, isolating and recovering from subsystem failures faster than possible with current methods and reduce ground operations and maintenance costs through process automation and systems autonomy.

KSC currently leads the Agency-wide work for In-Situ Resource Utilization (ISRU), where capabilities being developed will enable affordable and sustained human presence throughout the solar system by allowing the in situ manufacturing of propellants and consumables—a "living off the surface" approach that greatly decreases the mass that has to be launched into space. A current project led by KSC is the development of an ISRU payload that could be delivered to the moon to demonstrate the feasibility and viability of ISRU. KSC also has recognized expertise in granular mechanics and regolith operations involving working with the surface materials of other destinations—excavation, conveyance (in and out of chemical processors), manufacturing and construction with regolith, site preparation, landing pad construction, prediction of rocket exhaust blast effects, etc. We have developed and performed next generation life support technologies, such as air and water recovery, wastewater recycling, and closed loop life support capabilities. KSC is a partner in in-space cryogenics storage and transfer technology development leveraging our unique skills and experience in cryogenic propellants. We partnered in the Robotic Satellite Servicing project as well and are responsible for the design and development of the propellant transfer modules and hose management flight systems, including maturing the technology readiness levels of the flow metering and pump motor control technologies for this project.

KSC will continue to seek opportunities that align with the Agency's research and technology priorities, and ensure our talented workforce is prepared for success. KSC will also continue to partner with other NASA centers, other government agencies, industry and academia in this technology development work.

Question 2d. What can my office do, and what can Congress do, to help KSC meet its technology development goals?

Answer. KSC has great expertise in research and technology. The largest emphasis areas of these multiple disciplines of technology development are in support of: (a) launch vehicles and ground systems (for government and commercial operators) and (b) surface systems technologies needed for surfaces other than earth. Due to the long, successful history of space vehicle launches, KSC is well-known for its processing and launch capabilities. In addition, KSC has unique capabilities in the research and technology development arena. KSC has the capability to perform low technology readiness level (TRL) research that can then be inserted in all types of systems on earth, other surfaces, and in space. External partners from other government agencies, industry, and academia have found KSC's technology development expertise significant in development of technologies important to many applications of societal benefit and to NASA's missions. Your help would be greatly appreciated in supporting NASA's budget request, including the request for $699 million in Space Technology to continue the agency's important technology programs.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KAY BAILEY HUTCHISON TO MICHAEL L. COATS

Question 1. In May the administration announced its decision to proceed with the Orion contract and in September it announced its plans and architecture for SLS. Since the announcement of decisions to proceed with Orion and the SLS, what has your Center been able to do that it previously was unable to accomplish?

Answer. The May announcement allowed the Orion-MPCV Program to proceed with its reorganization plans and initiate detailed planning of the Orion incremental development plan while executing the component and systems development already underway. The September announcement enabled Orion to formalize agreements with the Space Launch System (SLS) Program Office and with Headquarters/Exploration System Division for conducting the program-to-program integration and coordinating our activities. The SLS announcement enabled the planning to proceed for the first orbital flight test of Orion-MPCV in 2014 which was authorized in November by NASA Headquarters.

These announcements also helped alleviate uncertainties about these two central development programs, which all offices have used to solidify plans for the future.

For example, the Mission Operations Directorate was able to clarify its role in the 2014 flight test.

Question 2. With regard to the announcement of the decision on the Space Launch System, has your employee and contractor workforce become more stable subsequent to that announcement? Are you expecting any more layoffs or major adjustments in workforce?

Answer. The announcement of the Space Launch System, along with support of Orion (MPCV), the International Space Station and other development programs has had a positive effect on workforce morale. With the necessary contractor layoffs already completed, JSC predicts additional layoffs will be minimal. NASA continues to work with elected officials, community leaders and the contractor community to transition employees who were laid-off to new positions inside and outside of NASA.

Question 3. You each represent Centers with historically major responsibilities for human space flight programs. Obviously, there are many capabilities and considerable expertise at NASA Centers throughout the country. Would you please describe the specific steps you are taking to maximize the NASA "Talent Pool", wherever it is physically located, to not only help you fulfill your primary Center Roles, but contribute to the improved efficiency and effectiveness of NASA as a whole?

Answer. JSC has been working diligently to preserve the critical workforce skills and capabilities needed to support current and future programs. There are several specific measures that JSC is taking:

- JSC continues to prioritize investment in our student pipeline programs, including our Cooperative Education Program. These programs support NASA's goals of promoting Science, Technology, Engineering, and Math (STEM) education as well as developing the skill needs that directly feed our critical hiring pipeline.
- JSC continues to invest in development programs that prepare our workforce for future challenges. Many of our key leaders for the Space Shuttle Program have vast expertise in managing a large-scale program in the operations phase. At the same time they need skills in the development-phase of project management and we are working on placement and individual development opportunities that will develop those skills. JSC is also using the Program/Project Management Development Program—which involves participants from across NASA—to build competencies in leadership and program-level project management. The Project Leadership and Space Systems Engineering Development Programs are also designed to build capabilities NASA needs for the future.
- JSC has actively been seeking beneficial partnerships to utilize its capabilities and facilities at the center to help offset costs and maintain critical infrastructure. Most recently, Petrofac Training Services signed an agreement that allows them to do deep-water safety training at JSC's one-of-a-kind Neutral Buoyancy Laboratory.
- JSC has been partnering with industry to offset development costs and collaborate with major U.S. companies. JSC worked with General Motors on the development of the Robonaut 2—a humanoid robot now onboard the International Space Station.

The International Space Station Program, Orion Program, and Advanced Exploration Systems projects have helped ensure that critical engineering and scientific skills can be capitalized and used to benefit the next phase of NASA's exploration mission.

Mission Operations support is critical to the success of any future spacecraft's entry into service, and the work required to fly them successfully is critical to preserving the national asset that is NASA' Mission Control and Mission Operations Directorate.

JSC has been working internally and with the contractor community to identify critical skills and ensure that JSC can continue to lead in those areas.

Question 4. The Orion program is described as streamlining its government insight and oversight activities with a goal of a 70 percent reduction in NASA oversight. Can you please describe how that is intended to work and if you have any concerns with this innovative approach?

Answer. The Orion Program has taken steps and made a pointed effort to better define the traditional government role as oversight, management integration and inline work. Oversight is effectively "checking and independently verifying" contractors are performing the work defined as stated in contract requirements. Management Integration is the support to the program manager regarding strategic decisions including budgets, schedules, planning, reporting, stakeholder communications, contracts, etc. Inline work consists of direct NASA contributions to the devel-

opment of the spacecraft performed in-house, utilizing our unique expertise/facilities, rather than performing the work exclusively within the prime contractor workforce.

The total dedicated oversight reduction is closer to 60 percent and consists of civil servant and support contractor work force. This number is based on the civil service and other contractor support categorized as dedicated oversight/insight, inline and program management integration.

When Orion reduced oversight, it also reduced management integration to core levels of support, roughly a 50—60 percent reduction. Orion also took advantage of NASA's unique expertise by redirecting the civil service workforce to perform inline work and in doing so, realized direct and indirect benefits. This newly redirected work increases the value of the government's performance and leverages the unique skills and infrastructure of the NASA team. NASA further benefits by acquiring a deep level of insight into critical areas by being directly involved in the contractor teams while performing these inline assignments.

Question 5. Can you please provide an overview of Orion/ highlights and accomplishments to date?

Answer. NASA has announced plans for the first Exploration Flight Test (EFT–1) of the Orion spacecraft in early 2014, which will support the new Space Launch System that will take astronauts further into space than ever before.

This test will acquire critical re-entry flight performance data and demonstrate early integration capabilities that benefit the Orion, Space Launch System, and 21st Century Ground Systems programs.

The first Orion-like docking system test was conducted on STS–134 as part of the Sensor Test for Orion Relative Navigation Risk Mitigation (STORRM). The orbital rendezvous verified the successful operation of the Orion's next generation docking sensor, a critical technology needed for future space exploration missions.

The Orion team has already completed critical subsystem tests and production milestones to meet these flight test objectives, such as completion of the first Orion crew module, pad abort flight test and other subsystem tests, preliminary design review, software design, ground test vehicle tests, water drop tests and facility renovations at Kennedy Space Center. The program also successfully completed the initial phase of the formal safety review process.

The Orion team completed a series of structural, acoustic and vibration tests at Lockheed Martin's Reverberant Acoustic Laboratory in Denver as they progress toward Orion's orbital flight test. After testing is completed, this vehicle will be sent to Langley Research Center in Virginia for a series of landing tests at the new Hydro Impact Basin, which will be used to validate and certify all human-rated spacecraft for NASA.

The Orion team at Michoud Assembly Facility in New Orleans began fabrication of the Orion spacecraft slated for the EFT–1 orbital flight test. After completion of weld operations at Michoud, the spacecraft will be sent to Kennedy Space Center's Operations & Checkout Facility for continued processing through final assembly and testing.

At the Lockheed Martin Exploration Development Lab in Houston, the Orion Hardware/Software Integration team completed its first successful integration test that demonstrated Orion's avionics hardware and flight software can perform a high-speed orbital entry from a deep space mission. These tests are critical during the early spacecraft development cycle to ensure the avionics and software is compatible before the flight test vehicle is completed.

The Orion program has conducted a vigorous parachute air and ground test program and provided the chutes for NASA's successful pad abort test in 2010. The lessons learned from this experience have improved Orion's parachute system.

Question 6. What does the proposed Orion test in 2014 mean for the workforce at JSC? Does this represent part of a larger body of initial work that will need to be done for mission control and management of this mission and other missions beyond low-Earth Orbit?

Answer. The flight test specifically addresses the mitigation of 10 of the top 16 risks to the crew and mission including the parachutes, the thermal protection system, separation of the forward bay cover, the onboard avionics and software and the various flight systems. The flight test also allows early integration of hardware, processing and operations experience with the new exploration systems. The ground operations team at the Kennedy Space Center and the mission operations team at Johnson Space Center will both be involved in the test.

Orion's EFT–1 allows the teams to focus on real-world flight test objectives that are derived to mitigate risks while moving forward on core systems development.

Doing so provides the opportunity to sustain critical ground and flight operational skills and validate ground hazard analysis and very specific hazard controls.

The EFT–1 will be a pathfinder for pre-launch, launch, range safety, recovery and de-servicing/refurbishment processes for the integrated exploration team. It also will demonstrate integrated vehicle performance for ascent, on-orbit, and high-energy entry from deep space. The test will allow the opportunity for all elements of NASA's exploration program to be tested together, exercising flight regimes, mission and recovery operations that have not been seen by a spacecraft designed for human flight in almost 40 years.

Question 7. Mr. Coats, your Center is home of Mission Operations Directorate and Shuttle Mission Control. The high caliber of these teams is well known. What have you been able to do to preserve some of these specialized skills and experienced individuals in the absence, now, of active space shuttle operations? Are there any support roles for the space station that would be available to preserve some of these unique capabilities?

Answer. JSC has a world class Mission Operations Directorate (MOD) that is controlling and operating the ISS 24/7. With the retirement of the Shuttle, new opportunities have been pursued to preserve the critical skills of that team: the development of Mission Operations strategy for the Orion Program operations and collaboration with the commercial partners about our interaction with them during NASA commercial flights.

In preparing for the transition, MOD ensured that experience in all technical areas, particularly those that are launch and entry related, are retained in the MOD work force. In some areas MOD may be down to few individuals, but it still maintains the full range of technical expertise in the division.

JSC has archived the MOD launch and entry experience through a detailed series of video-documentaries that include simulation runs in mission control and the simulators and interviews with MOD leaders and Shuttle veterans. The remaining Shuttle-experienced personnel have been redeployed to ISS operations support, Orion and SLS development, commercial crew development and direct support to JSC Engineering. In parallel, MOD has aggressively pursued roles with next generation NASA or commercial spacecraft to leverage the expertise, experience and operations culture unique to MOD.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KAY BAILEY HUTCHISON TO ROBERT M. LIGHTFOOT

Question 1. In May the administration announced its decision to proceed with the Orion contract and in September it announced its plans and architecture for SLS. Since the announcement of decisions to proceed with Orion and the SLS, what has your Center been able to do that it previously was unable to accomplish?

Answer. The NASA Authorization Act of 2010, released in October 2010, necessitated immediate planning to meet an ambitious schedule. Significant progress was made in the first half of calendar year 2011 to position the agency to achieve this goal including a Requirements Analysis Cycle and Mission Concept Review that yielded an informed architecture decision. The formal approval of the architecture enabled an initial system design to which credible development schedules and budget requests are anchored, and the execution of acquisition plans to implement contracts to procure the various elements of the SLS system and retain key Shuttle assets applicable to the SLS design selected otherwise contracted for excess or archive. Also since the announcement, the Program has been given the necessary authorities, including a Key Decision Point (KDP–A) memo and Formulation Authorization Document authorizing the program to proceed from pre-formulation into formulation that will enable the Agency to meet the programmatic and technical requirements necessary to achieve major review milestones leading to the next KDP, graduating the program from formulation to implementation.

Question 2. With regard to the announcement of the decision on the Space Launch System, has your employee and contractor workforce become more stable subsequent to that announcement? Are you expecting any more layoffs or major adjustments in work force?

Answer. Given the announcements of the Space Launch System (SLS) and the passage of NASA's 2012 appropriation, the employee and contractor staffing levels have become more stable. MSFC will continue to balance supply with program/project demand to ensure that capabilities are affordable and align with long-term strategic goals of the Agency. In doing so, we do not anticipate any major adjustments to current workforce staffing levels.

Question 3. You each represent Centers with historically major responsibilities for human space flight programs. Obviously, there are many capabilities and considerable expertise at NASA Centers throughout the country. Would you please describe the specific steps you are taking to maximize the NASA "Talent Pool", wherever it is physically located, to not only help you fulfill your primary Center Roles, but contribute to the improved efficiency and effectiveness of NASA as a whole?

Answer. MSFC has proactively maximized the use of the Agency's talent pool by meeting with multiple Centers to discuss how best to partner on current and future programs/projects. Some specific capabilities-driven areas of collaboration include space environments, fluids, structures and propulsion testing, composites, cryofluids and acoustics. Additionally, in November, the Directors from Glenn Research Center, Langley Research Center, Marshall Space Flight Center, Stennis Space Center, Dryden Flight Research Center, Kennedy Space Center and Johnson Space Center hosted joint all-hands forums at each Center location which allowed employees to understand activities underway at other Centers and to promote collaboration between Centers to improve the efficiency and effectiveness of NASA.

Recently, the National Institute for Rocket Propulsion Systems (NIRPS) was created to stimulate collaboration and partnerships between NASA, the Federal Aviation Administration, the Department of Defense, industry, and academia. Its establishment provides stewardship of our Nation's propulsion capabilities while recognizing their vital role in national security, economic competitiveness and the continued exploration of space. The NIRPS will address key challenges facing the rocket propulsion industrial base such as:

- Reducing development and sustainment costs for missile and rocket systems
- Supporting the competitiveness and resilience of the industrial base
- Fostering access to facilities and expertise across government, industry and academia
- Developing and implementing an integrated science and technology plan for propulsion systems
- Invigorating the Science, Technology, Engineering and Mathematics (STEM) pipeline
- Collaborating across agencies for missile and rocket propulsion system development

Question 4. In Mr. Bolden's testimony he states that the SLS Program has streamlined its interfaces, workflow, and decision-making process. As head of the leading Center for SLS development, can you give examples of how the Program is going to be more streamlined and more efficient?

Answer. Across the SLS Program, there is an unprecedented focus on affordability. Due to the fiscally constrained budget environment, it is imperative that SLS define and implement an affordability strategy that challenges the culture to become more cost conscious in every single activity at each organizational level.

One area in particular that is part of the affordability strategy is government insight and oversight of contracted activities. SLS management has set forth a deliberate strategy for implementing the appropriate level of risk-informed insight and oversight levels. According to this strategy, insight levels will be based on risk assessments of known historic failures in the aerospace industry, past performance of industry partners, as well as inherent complexity and design challenges. Oversight will be discrete based around major milestones and events rather than near-continuous coverage. This approach will limit government involvement to provide cost savings within the government workforce as well as savings on the contractor side due to fewer interactions.

Another area is that of reduced documentation and applied standards. NASA and the SLS Program have reduced the number of Data Requirements levied on the contractor, which translates to contract cost savings. Additionally, rather than levying NASA-unique standards, industry standards are being used to the maximum extent practicable.

A third area of affordability measures is that of robust designs and margins. To continue to drive down costs, all development and operational decisions will consider affordability with associated technical implications. All options, including questioning unaffordable requirements, will be pursued. This will create opportunities to exchange excess performance for cost savings thereby improving affordability. An example of this is the utilization of heavier materials, which may decrease performance capability but provide cost savings. Maintaining margins in technical capability rather than chasing high performance capability as in the past will be an enabler to this strategy.

Question 5. How is the Program minimizing requirements and dealing with the age-old problem of "requirements creep"?

Answer. The imperatives of affordability and sustainability have been basic elements underlying all planning for a new era of efficient and effective space exploration. The Agency's Human Exploration and Operations Mission Directorate (HEOMD) has embraced requirements control as a fundamental tool in meeting this challenge. As a result, a concerted effort to levy only the most necessary requirements on the SLS Program has yielded a greatly reduced number of "top-tier" or HEOMD requirements. The Mission Directorate is thereby delegating responsibility to the programs to meet a set of fewer prescriptions while still meeting the goals and objectives. Likewise, the SLS Program has made a similar concerted effort to reduce "second-tier" requirements. In fact, this second tier set of requirements levied by the SLS Program has been reduced by an order of magnitude when compared to similar large-scale programs/projects. Additionally, system requirements and associated verification will be defined early and changes minimized, technical content will be prioritized to clearly delineate needs from wants, and specifications, standards, and procedural directives will only be imposed on contractors where a clearly defined need exists.

Question 6. Can you describe what aspects of the SLS development will be competitively bid, and what sort of timeline those competitive processes will occur?

Answer. The Draft NASA Research Announcement (NRA) for the Advanced Booster Engineering Demonstration and Risk Reduction effort was released on December 12, 2011. The SLS Program conducted an Industry Day with prospective offerors on December 15, 2011. The final solicitations will be issued in the first quarter of calendar year 2012; proposals are expected in the second quarter of calendar year 2012; and awards made later in calendar year 2012 with performance starting in October 2012.

Advanced Development activities will be focused on evolving the vehicle to the 130 metric ton capability with an emphasis on affordability, safety and reliability. Specifically, Advanced Development will focus on the areas of concept development, advanced development in propulsion, structures, materials and manufacturing, and avionics & software. This will result in multiple awards also in October 2012 after a solicitation release in the first quarter of calendar year 2012. These procurements will be open to both industry and academia.

Acquisition strategies for other elements, such as future core stage engine, and spacecraft and payload adapter and fairing, will be developed over the next several years consistent with the budget profile and anticipated need dates for the actual components.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN BOOZMAN TO ROBERT M. LIGHTFOOT

Question 1. I understand your greatest focus at Marshall Space Flight Center is on vehicle development. But you also have a space station payload operations center there, as I understand it. Can you describe that activity, and how it integrates with over-all station operations—and how it might be impacted by increased commercial use of the space station within the National Laboratory activity?

Answer. Marshall Space Flight Center's (MSFC) Payload Operations Center (POC) has coordinated scientific research carried out aboard the International Space Station (ISS) since 2001. This activity includes supporting operations around the clock, 7 days a week; integrating research requirements; planning and safely executing science missions; managing the use of ISS payload resources; conducting science communications with the Station crew; and managing payload commanding and data and video transmissions to and from ISS. The POC teams also train Station crewmembers and ground controllers to operate and maintain U.S. science experiments aboard the Station. The POC acts as a Backup Control Center for Mission Control Center—Houston (MCC–H) in the event of a catastrophic event. While this is primarily a hurricane season (June to November) contingency, the POC can be activated in the event of the unanticipated and immediate loss of capability at MCC–H. In this mode, the POC would be able to handle U.S. Lab operations and provide limited support to the International Partners.

The POC provides a critical interface to NASA's International Partners and the research community utilizing the U.S., Japanese, and European science labs. In this role, the POC synchronizes payload activities among the Partners, and provides data and video transmissions to the Partners' sites. As the National Lab community grows and becomes an integral part of the research conducted aboard Station, the POC team will perform these integration functions to ensure that the commercial

research community can successfully train, plan, and execute their science investigations. In the future, the MSFC POC will have increased capabilities, and will apply its experience to the next generation of U.S. human space systems. The POC has been approved to support around-the-clock ISS payload operations through 2020, including the accommodation of increased science throughput and payload operations associated with the advent of six-person crews in 2009. Since 2009, the POC has incorporated full backup command and telemetry capabilities for the International Partners into the Backup Control Center architecture. In 2012, the Station will complete an upgrade to the avionics systems which will increase bandwidth and communications capabilities, enabling the POC to realize increased communications efficiencies.

Question 2. I have posed this same question to Administrator Bolden, but I would like your response to it, including any additional details or points that may not have been included in the Administrator's response. Regarding the competition for the advanced booster, what is the planned timeline, from start to finish? How firm are these timelines? In addition, how will NASA ensure that the competition for the advanced booster project will be executed in fair manner? Could you give details regarding these steps?

Answer. The Draft NASA Research Announcement (NRA) for the Advanced Booster Engineering Demonstration and Risk Reduction phase was released on December 12, 2011, to improve the competitiveness of competing propulsion technologies and business cases before work begins on the actual Design, Development, Test and Evaluation (DDT&E) of the final booster configuration. The SLS Program conducted an Industry Day with prospective offerors on December 15, 2011. The final solicitations will be issued in the first quarter of calendar year 2012; proposals are expected in the second quarter of calendar year 2012; and awards made later in calendar year 2012 with performance starting in October 2012. These dates are firm.

The SLS Advanced Booster Engineering Demonstration and Risk Reduction acquisition effort will increase affordability, performance, and reliability confidence of an Advanced Booster concept which will enable SLS to evolve to a 130 metric ton lift capability, and reduce risks for both liquid and solid Advanced Boosters concepts. The notional SLS Advanced Booster will require a significant increase in thrust from any known existing solid or liquid booster in the U.S. inventory. The DDT&E effort will be solicited in the 2013–2014 timeframe, after results are received from the risk reduction effort. SLS is targeting the first flight of the Advanced Booster for the third SLS flight in the 2023 timeframe.

First, the SLS Program is engaging industry early in the acquisition process to ensure requirements and the solicitation are written to maximize competition. Potential offerors have been asked for their comments in a Request for Information issued in October, then through the comment process on the draft NRA, and have also been invited to sit one-on-one with the proposal evaluation team. Second, a detailed technical library is being provided to maintain competitiveness across all potential offerors. Finally, the evaluation criteria in the solicitation have been thoroughly reviewed within the Agency to ensure the best solicitation to yield competitive proposals and an equitable evaluation.